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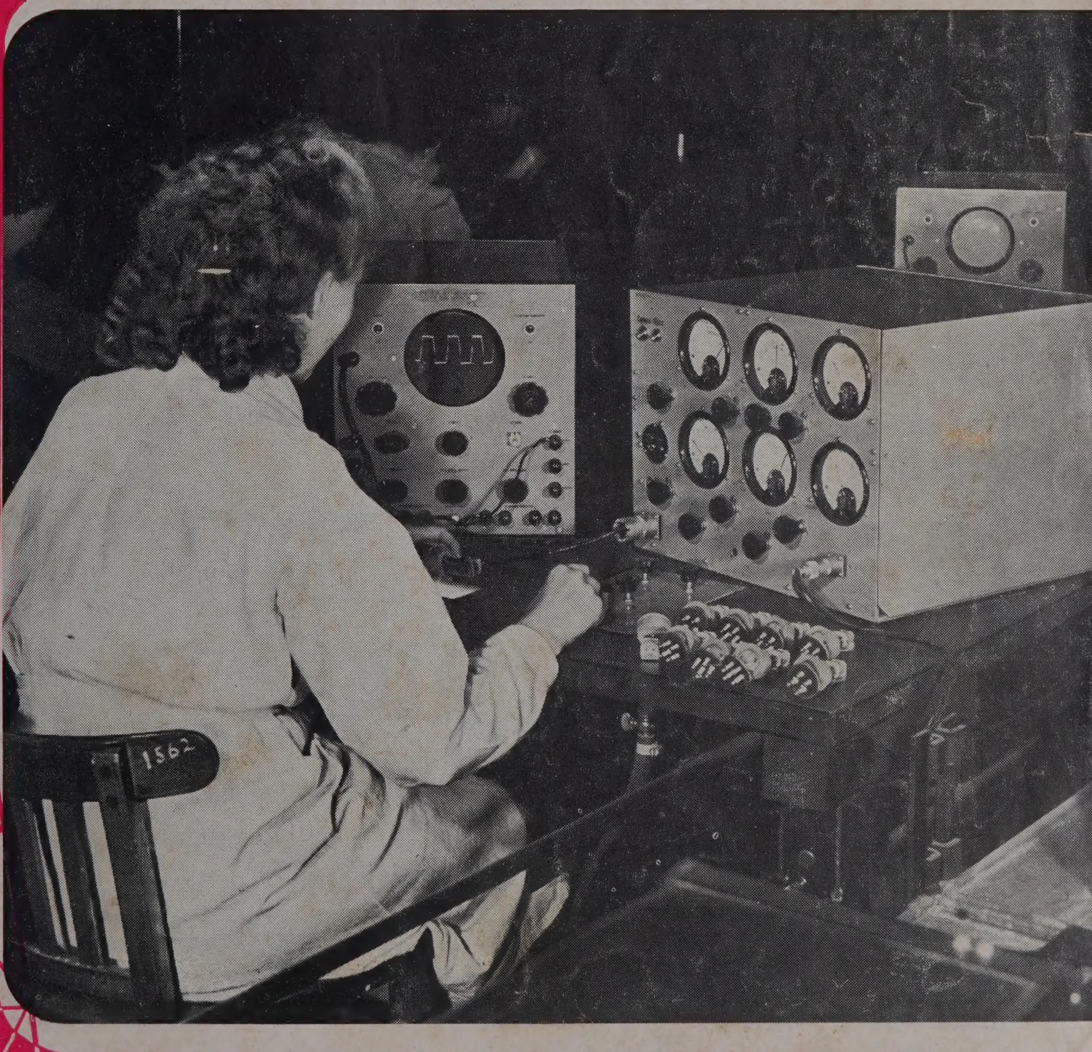

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RADIO and ELECTRONICS

Vol. 3, No. 4 — 1st July, 1948

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OUR COVER

This month's cover picture shows the final testing of vibrators in an English factory where production of these components has recently commenced. The wave-form on the oscilloscope is that of a perfect vibrator, but it certainly does not appear to have been inked in for propaganda purposes, as the detail is far too good. Besides, we have a copy of the original photograph!

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WELLINGTON.

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46 Mercer Street, Wellington.

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AUCKLAND REPRESENTATIVE:
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150 Queen St., Auckland.
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Printed in New Zealand by H. H. Tombs, Ltd., Wingfield Street, Wellington.

A NEW PRINCIPLE IN HIGH-FIDELITY REPRODUCTION

In the field of electronic circuitry it is never safe to say that there is nothing new under the sun, and this is amply demonstrated by the appearance in America of a new principle which appears at first sight to possess the solution to some of the outstanding problems in connection with high-fidelity reproduction. Its somewhat high-sounding title is "Dynamic Noise-Suppression."

The manner of its working is not easy to describe in a few words, but we will do our best in the limited space available, and perhaps follow up in a later issue with a more comprehensive article on the subject. Briefly, what the dynamic noise suppressor does is to ensure that the frequency response of the audio system to which it is applied is at any instant only wide enough to pass those musical frequencies which are present at that instant. Now to perform such a feat seems, on the face of it, impossible, and in fact would be but for two facts, well enough known in themselves, which have hitherto not been applied to the problem. Suppose, for instance, that we have a system in which the high-frequency response is limited to, say, 4000 c/sec., except when an initiating signal causes the range to be extended. The question arises as to how this is to be brought about without using for the control voltage something that is derived from the high-frequency part of the spectrum. If this part of the audio range is itself used to open up the response, then we find ourselves in the situation that high-frequency noise, which we have set out to eliminate from the reproduction, will itself cause the high-frequency "gate" to open, so that we are no better off than before!

The two facts referred to above are such that the topmost frequencies, and likewise the very lowest, can be allowed to pass through the amplifier **by virtue of control exerted by parts of the frequency range that are themselves outside the bands to be controlled.** Thus, scratch, at the one end, and hum or rumble at the other, cannot cause the "gates" to open except when there are musical signals in the ranges where these noises occur. The net result is that for the greater part of the time, the frequency response of the system is severely restricted at both ends, so that low and high-frequency noises cannot be heard, but at the same time, this restriction is not noticed by the ear, since there are no significant signals in the restricted portions of the spectrum at the times when they are restricted. Of course, when the gates are open, and the extreme high and/or low frequencies are able to be heard, the noises are audible, too, but only to a limited extent, on account of the presence of the musical signals, which tend to drown them.

The above must not be taken to mean that a method has been found whereby the extreme upper register need not be reproduced clearly, and with an absolute minimum of distortion; requirements here are as stringent as when the dynamic noise suppressor is not used.

How, then, does the suppressor work? And what are the principles which enable the frequency ranges to be controlled by means of signals external to themselves? The latter question must be answered first. At the high-frequency end, we have the fact that the highest FUNDAMENTAL musical frequency found in the orchestra is in the region of 5000 c/sec. It therefore follows that any sounds heard above this frequency must be in the nature of harmonics of the fundamental notes produced by the instruments. The range above 5000 c/sec. is also the one in which the objectionable sounds called "needle scratch" occur. It is therefore possible to derive a control signal, whose function is to open the high-frequency gate, from the middle-high audio range, say from 2000 to 4000 c/sec. At the other end of the scale we have the fact that hum and the rumble due to the record and turntable have very few components at frequencies higher than their fundamentals, which are very low. On the other hand, low-frequency musical notes, such as that from a bass drum, almost always possess a large proportion of higher order harmonics. It is thus possible to derive a further control signal for opening the low-freqquency gate, from the middle-low range, say from 200 to 1000 c/sec.

The control signals referred to are obtained by the commonly used system of half-wave rectification, succeeding suitable filter circuits, whose purpose it is to see that only the appropriate frequency ranges produce the control signals. Once these signals have been produced, they are applied to the gate circuits, which consist basically of high and low-pass filters, whose cut-off frequencies can be altered at will by means of reactance tubes, which are connected in the filters either as capacities or inductances, forming elements of the filter circuits. This scheme is very elegant and is capable of almost any degree of elaboration. For broadcast transmitting use, elaborate filters are used with two or more sections, and containing two or more reactance tubes, making a total of four or six of these circuits. Again, the number of variables is very great, since such matters as the level at which the gates open, their rate of opening and closing, and many others, are all capable of variation to suit particular conditions. At the same time, much simpler circuits have been developed for use in receivers and gramophone amplifiers.

It appears that the system described might have very great advantages, even allowing for the professional enthusiasm of the American writers who have described the system in the technical press. It would certainly not be simple to design and construct, and there are a number of points that would need very careful consideration if it was to be entirely successful. The fact remains, however, that Scott, the inventor, has hit on a very ingenious plan which strikes at the very root of the well-known reluctance of the public to accept wide frequency response.


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THE ELECTRON MICROSCOPE

By C. R. LESLIE

"The scientific representative of New Zealand in London, Dr. E. Marsden, has advised the Department of Scientific and Industrial Research that the construction of an electron microscope for the use of research workers in the Dominion will be completed in a month. The instrument is being made by Metropolitan Vickers, and on arrival will be installed at the Dominion Physical Laboratory, Lower Hutt."—("The Dominion.")

PART I

INTRODUCTORY

In light of the above news item, it is felt that readers may welcome a general description of the instrument and of its main uses. Without going too deeply into the physics involved, it is possible to give a working idea of the construction and operation of the electron microscope. Such a discussion falls naturally into three sections: (1) A brief history of the development and of the reasons therefor, (2) various types that have been developed and construtional features of an instrument similar to that mentioned above, and (3) a brief description of the main uses and problems involved.

HISTORY OF DEVELOPMENT

Perhaps, before touching on the history, it will be advisable to consider briefly the reasons leading up to the development. Some people may question the need for a complicated and costly electronic instrument when very powerful and efficient optical microscopes are already in existence. But the chief reason lies in the very limitations of the optical microscope where light rays are used. It is generally appreciated that the colours of the spectrum are due to differences in the wavelength of light and that the eye is more sensitive to certain portions of the spectrum than to others. Practical experience has shown that the blue-green portion is the most suitable for microscopical use. The wavelength of this portion is 0.5 micron or 0.002 mm.—a micron being one-thousandth of a millimetre. The greatest resolving power of the human eye—that is, the power to distinguish two closely adjacent points as separate entities—is 0.1 mm. In other words, the naked eye cannot separate two points unless they are at least 0.1 mm. apart, and as this distance is only 200 times greater than the wavelength of a blue-green light ray it will be readily appreciated that considerable difficulty is likely to be experienced in obtaining very large magnifications.

We may define useful magnification in terms of resolving power, and the limit will be the smallest separation that can be made visible by an optical lens system. From this we see that the maximum useful magnification now becomes the ratio of the resolving power of the human eye (0.1 mm.) to that of the lens system. In a high-class instrument, this latter will be of the order of 0.0001 mm. Hence the useful magnification becomes

$$\frac{0.1}{0.0001} = 1000 \text{ diameters.}$$

By special design and materials, 2000 diameters have been actually obtained, while by the use of ultraviolet rays in association with quartz lenses and a fluorescent screen 3000 diameters have been achieved.

The reason for the limitation of the resolving power of an optical lense system is due to the phenomena of "diffraction rings." The image of a point as seen through a lens system is a disc surrounded by diffraction rings, whose extent depends on the wavelengths of the light rays being used. If the point is large in comparison with the wavelength, the diffraction rings are not important, but if the **separation between two object points is small in comparison with the wavelength,** then the rings will overlap and make it impossible to distinguish the two object points at all. It has been found that the critical separation distance for optical systems is half a wavelength, so that if the two object points are less than half a wavelength apart, **no matter what magnification is used,** they cannot be visibly separated. Thus, for blue-green light, the critical separation distance is 0.004 mm., and this sets a dead-line for useful magnification by an optical lens system.

Another limitation is experienced in practice, and that is the lack of depth of focus at large magnifications, which necessitates the reduction of solid objects to as near a two-dimensional plane as possible. This factor prohibits the useful examination of living bacteria.

There is no need to delve into the history of the "electron," though it may be of interest to know that the word first appeared in print in a paper by Dr. Johnstone Stoney, of Dublin, in 1891. But, what is important, in that it may be considered as the first step in the development of the electron microscope, was a theory propounded by de Broglie in 1924 that free electrons in movement behaved as if they possessed definite wavelengths. De Broglie evolved a formula which stated that the wavelength was

$$\sqrt{(150/E)} \times 10^{-10}$$

where E is the accelerating potential.

The second step was the discovery of wave mechanics in 1925 by Schrodinger, who combined de Broglie's idea with Hamilton's Analogy of Dynamics and Optics. The third advance was H. Busch's discovery in 1926 of the lens property of axially-symmetric electric and magnetic fields, which laid the foundations of geometrical Electron Optics.

These three discoveries showed that free electrons could be used as and were similar in action to ordinary light rays in that they had definite wavelengths dependent on the accelerating voltage, that they could be deflected like light rays from a mirrored surface, and finally could be focused like light rays through a lens system. But the electron system had the overwhelming advantage of having the wavelength variable "at will" by the regulation of the accelerating potential. Thus, using de Broglie's formula, we find that when E = 60,000 volts, the wavelength becomes 0.5×10^{-5} microns! This can be compared with the 0.5 microns of the wavelength of blue-green light rays. Thus, we now possess a "synthetic" light ray whose wavelength is 100,000 times shorter than that of blue-green light. The significance of this is that, if an optical system at its most efficient will give us a magnification limit of 2000 diameters, with a theoretically perfect electron microscope we should be able to achieve a magnification 10^5 as large, or 200,000,000 diameters!

Actually, this fantastic figure has not been obtained owing to technical difficulties, but already a useful magnification of 200,000 diameters has been achieved, thus marking a spectacular advance on optical methods.

The comparatively recent advances made in valve and television technique have made the practical development of the electron miscroscope possible. For great magnification, it is necessary to have a fluorescent screen of very fine grain which can also withstand a concentrated electron bombardment without burning out. The electron lens system formed another field for intensive research in order to produce a sharp focus in combination with appreciable depth, together with the elimination of various error tendencies. These factors held up practical achievement until quite recent years, so that it is only fair to say that the development is still in its infancy, and that when remaining hurdles are surmounted even more startling results may be expected.

TYPES OF INSTRUMENTS

There have been three distinct types of microscope developed so far:

(1) Following closely to television practice and using a scanning principle in which a finely-focused spot of less than one-millionth of an inch in diameter was traversed over the object in a similar manner to a television camera, the resulting current fluctuations being then transferred to a television receiver for amplification and reproduction. With this type, only "moderate" magnifications from 3000 to 8000 diameters were achieved.

(2) A straightforward electron microscope using electrostatic lenses. One objection to this type was the varying acceleration potentials required, which caused proportional variation in the electron velocities (and hence in wavelength) along the transit path, and this tended to give faults similar to chromatic aberration in an optical system.

(3) A similar instrument to the above, but using electro-magnetic lenses throughout. In this type, the electron velocity remains uniform, and focusing is achieved by controlling the strength of the magnetic fields of the lenses. This last type is becoming accepted as the standard system, and we will discuss it in more detail.

The main essentials are: (i) An electron generating source which consists of a television tube "electron gun," or cathode, and associated grids; (ii) a system of electronic lenses for focusing and magnification, which will be dealt with in greater detail later; (iii) a very pure D.C. source of high voltage of some 60 kilovolts, which is produced by a special oscillator giving a frequency of 30,000 c/sec. (which is more readily smoothed than the mains frequency of 50 c/sec.). In American instruments, the frequency is 32,000 c/sec. because of the 60 c/sec. mains. It will be seen from this that the supply frequency is obtained by frequency multiplication of the mains supply. And (iv) a fluorescent viewing screen of extremely fine grain.

Subsidiary requirements are perfect screening from extraneous interference, methods of viewing or photographing the screen, cooling systems, and methods of rapid evacuation after insertion of the object specimen, and, finally, what is almost a separate field of research, methods of mounting the specimens.

A description of the "gun" and supply source need not be dealt with here, as they follow normal though specialized lines. The "heart" of the instrument may be taken to be the lens system, and this calls for special attention.

ELECTRON LENSES

Without going deeply into the question of electron optics, it will be at least necessary to touch on some of the main principles if the action of the lenses is to be fully understood. Those readers desiring to go deeper into the subject may consult "Electron Optics," by L. M. Myers (Chapman & Hall, 1939). We have already referred to Hamilton's Analogy; in this he states that the trajectory of a material particle in a conservative field, i.e., in a field in which the force can be derived from an ordinary potential, can be likened to the path of a light ray in a medium with suitable refractive properties. The Principle of Least Action of dynamics states that the "action" or energy transfer connected with the trajectory along which a particle will **actually** travel from one given point to another, will be less than for any other geometrically possible path, and the "action" W may be defined as the time integral of the kinetic energy. That is to say $W = \int \frac{1}{2}mv^2\,dt$.

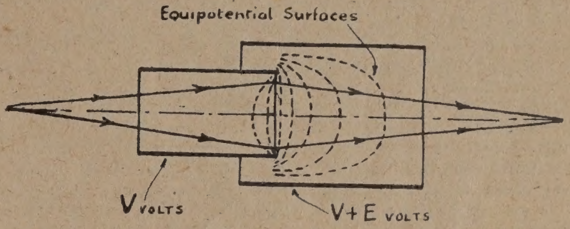

Fig. 1.

Now the velocity v can be written as ds/dt where ds is the length of the path element. Hence we may write $W = \frac{1}{2}m \int v\,ds$.

The foundation of geometrical optics is Fermat's Principle of Least Time, which states that in a medium of refractive index n the velocity of light is c/n where c is the velocity in vacuo. Hence, the transit time between two points is $1/c \int n\,ds$, and this must be a minimum. Comparison of the two laws shows that if the refractive index of the medium is assumed to be proportional to the electron velocity, then the dynamic trajectory of the electron, and the light ray, become identical.

In electron optics we are concerned with only one cathode, which emits electrons whose initial velocities are negligible compared with the later velocities acquired in the field, so that the refractive index is proportional to the square root of the potential measured from the cathode as zero level. This is a function of position only in just the same way as the refractive index of geometrical optics is a property of the medium—that is, a function of the position. It can be shown that the analogy also holds in cases where initial velocities cannot be neglected.

The main practical difference between light and electron optics lies in the fact that, whereas the refractive index of the light media varies within the limits of 1–2, in an electronic device in which the electrons emitted from a barium cathode are ultimately accelerated to 100,000 volts, the refractive index will vary between 1 and 1000! This fact explains the great difference in magnification possible.

Let us first consider the electro-static lens, as being simpler in action. Fig. 1 represents such a lens, consisting of two concentric tubes held at different potential levels. The curved lines represent

sections of equipotential surfaces which intersect the axis at right-angles and which are virtually spherical at the point of intersection. If we imagine the spaces between the surfaces as being filled with a "medium" whose refractive index is proportional to the square root of the potential, we obtain a series of "lenses"—

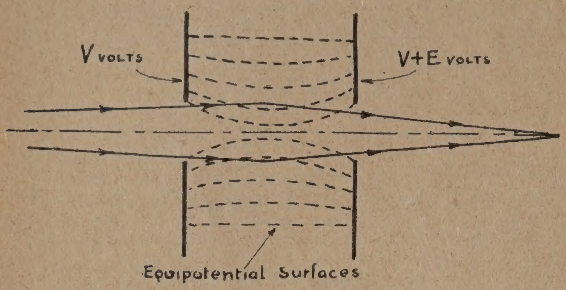

Fig. 2.

distorted, it is true, away from the axis, but symmetrical at the axis. Now, since a system of lenses can be considered as one lens in effect, it is easy to see the analogy to the optical lens.

Alternatively, we may illustrate the point by a system such as Fig. 2, in which we have two discs at different potentials and a hole drilled in each centred on the common axis. The dotted lines represent equipotential surfaces, and it will be seen that they tend to condense the electron paths.

A somewhat similar action takes place with the electro-magnetic lens, though it is more complicated, since the force exerted on a moving electron is at right-angles both to the direction of the field and to the direction of motion. The result is a twisting of the electron paths around the axis while in the immediate field of influence. This is shown in Fig. 3,

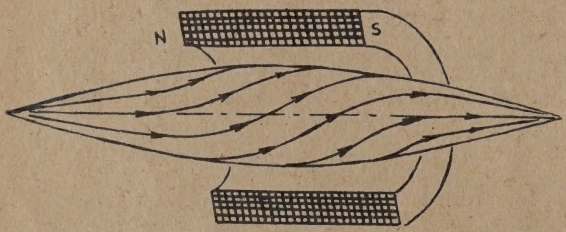

Fig. 3.

where it will be seen that the electron paths from the point A at first diverge in the direction of motion and then twist round the axis, as indicated by the arrows, and then emerge as a cone centred on the axis, the divergence and convergence being governed by the polarity of the coil. Optical lenses offer no parallel to this twisting effect. The extra length of the path travelled by the electron is not a serious consideration, because it has been shown that the electron is speeded up during the action in a proportionate manner, so that, in effect, the overall velocity remains unchanged.

Fig. 4 shows in a diagrammatic way the actual construction of an electro-magnetic lens of the type ordinarily used—called an "ironclad" concentrating coil. The winding is totally enclosed in an iron shell except for a very small air gap across which an intense flux passes so as to exert a very intense focusing effect. The exact design of these lenses is the subject of much current research in order to overcome spherical aberration tendencies. The latest trend is to utilize extremely small apertures of the order of 0.02 mm. diameter. This restriction reduces the "illumination" to less than 1 per cent., but it materially improves the definition and assists in obtaining a greater depth of focus, and is akin in effect to the old "pin-hole" camera. The point is of the utmost importance, as it enables the whole of a small object to remain in focus, and not only one plane of it as with the optical system.

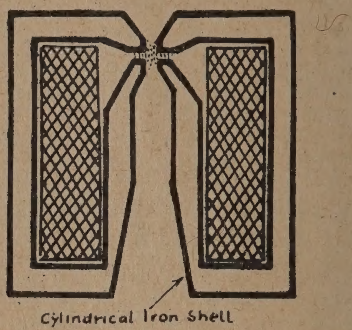

Fig. 4.

The next point to consider is whether such lenses are GOOD lenses in the optical sense. The latter, unless "corrected," can suffer from many defects—fortunately, only three of them can apply to our subject—namely, (i) spherical aberration, (ii) chromatic aberration, and (iii) coma. Of the three, the first is the most important in electron microscopy, and is illustrated in Fig. 5, which represents electron paths through a lens. The lesser divergent paths converge at a point P on the axis, called the Gaussian

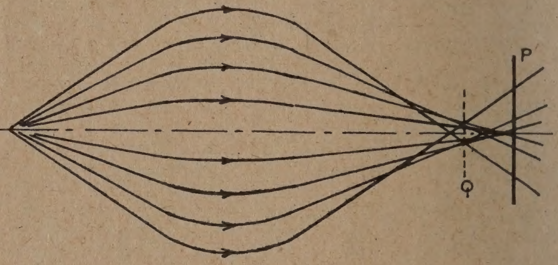

Fig. 5.

point, but, as the angle of divergence increases, the convergent point moves towards the origin—that is, ahead of P, so that a screen placed at P will see these latter rays as a disc. Therefore, we have to arrive at some compromise, and usually the viewing plate is placed at a point in front of P at a position of minimum cross section, such as Q, it being remembered that the strength of a lens increases with the angle of divergence.

"Chromatic" aberration is caused by irregularity in electron velocities (differing wavelengths as in light optics), and can only be catered for by cathode shield design—so as to only pass those electrons of a certain velocity—and as pure a D.C. voltage as possible. Electrons at different velocities will naturally converge at different points on the axis if the same strength of field is supplied to each.

(To be continued.)

How to deal with Single-ended Valves

Single-ended valves are by now no novelty to the designers and constructors of radio equipment. During the war, very great use was made of both the full-sized metal tubes and of the newer miniatures, and both were found to give excellent performance in all types of circuit. In the domestic receiver field, however, there seems to have been a certain reluctance to use such tubes as the 6SK7 in radio frequency amplifier circuits. Manufacturers and home constructors alike have shown a distinct preference for the types which have a top-cap grid whenever there is a possibility, as there is in R.F. circuits, of incurring oscillation through the close spacing of input and output leads. This reluctance is quite understandable, although it is also unfortunate, in that it prevents the designer from making use of some of the desirable features of the single-ended types.

At the present time, however, it is becoming apparent that some of us, at least, will have to make use of single-ended valves in R.F. and I.F. circuits. This is partly due to the fact that the import of American valves is at a standstill, and that, even if this situation no longer existed, the modern trend towards miniaturization would sooner or later make it necessary to face the problem of making single-ended valves behave properly in R.F. circuits. Again, the new continental and English Rimlock series of valves is just becoming available here, and these are all single-ended types. They also have excellent characteristics, and it would be a pity if designers failed to use them, simply because of their single-ended construction. We may be wrong, but in our opinion it will not be many years before single-ended valves have entirely superseded those with top-cap grids for use in new equipment. Because of all these things, it was felt that readers would welcome some information on the proper use of single-ended tubes, and some experimental work was done in our laboratory in order to justify some of our own ideas on the subject.

WHAT IS THE BASIC PROBLEM?

What, then, is the fundamental difficulty which, so far, has succeeded in retarding the use of these valves? We believe that it is almost entirely one of stability. The valve whose control-grid has its connection made through a cap on top of the envelope ensures, automatically, to some extent, that the input and output circuits of the valve shall be spaced by a reasonable amount. For this reason, the possibility of incurring oscillation, or at least instability, through poor lay-out of the parts of a single-ended circuit is fairly remote, always provided that there is adequate shielding between the input and the output devices themselves. Even when unshielded tuned circuits are used, and one is placed above the chassis so as to be near the grid-cap of the valve, the spacing and the shielding provided by the chassis itself are usually sufficient to prevent instability. The above statement does not hold nearly so well when there are two or more stages of R.F. or I.F. amplification in cascade, for here the gain is very much higher, and the fact that there are two stages places two top-caps and their leads above the chassis, so that there is now a possibility of capacitative or inductive coupling between them. Thus, where there is more than one stage, much of the advantage of the top-cap grid connection is lost. It is not generally realized that in such circumstances single-ended valves possess a very real advantage, as long as they are properly applied.

However, if single-ended stages are to be used, there is the difficulty that grid and plate leads of any one stage must of necessity approach each other to within a distance equal to the breadth of the valve socket. The problem therefore resolves itself into one of laying out the components and their wiring in such a way that, in spite of this, there is not enough feedback from the plate to the grid circuit of any one stage to cause trouble.

WHAT CAN BE DONE?

The valve manufacturers have come to the rescue here, at least to some extent. In the American single-ended metal series, there is a shield built into the locating spigot of the valve, and earthed to the shielding that is incorporated in the valve structure itself. In addition, the plate and grid pins are placed as far as possible from each other by making them diametrically opposite on the base. In many cases, such as in single stages of I.F., where the tuned circuits are shielded both from each other and from the wiring by their cans, the degree of shielding provided by the locating spigot is adequate as long as the leads to the grid and plate pins run directly away from the socket in opposite directions. The manufacturers also recommend that the screen by-pass condenser be placed across the valve socket at right-angles to the line through the grid and plate pins, so that when this component is wired with the outside foil connected to earth, the condenser forms an additional shield. If a single stage only is wired in this way, there will rarely be any trouble through feedback if the wiring has been neatly carried out, and if the unshielded leads carrying radio frequency currents are not too long. This amount of shielding has been found sufficient, too, where a single-ended stage is followed by one using a valve with a top-cap grid.

The miniature tubes, however, have no internal shielding which is as effective as the spigot-shield of the metal valves. Some of them have a small metal disc mounted inside, on the button base, concentrically with the ring of pins. Others do not have even this; but the sockets that are sold for these valves themselves incorporate a shield which corresponds in position and function with the spigot-shield of the metal valves. Some miniature sockets do not have these tubular shields between the contacts, and are to be avoided like the plague for stages of I.F. or R.F. amplification. And it is all-important to see that this shield is properly earthed.

USE OF COIL UNITS

The above precautions are all very well in the case of I.F. stages, and sometimes for R.F. stages if there is only one band, and the coils are well shielded. In multi-band R.F. stages, however, the situation is quite different, and there is some reason to complain of difficulty in applying the single-ended tubes. Here a different approach is required, as a little thought will readily show. Consider for a moment the usual type of coil-unit sold in the home-constructor market. This has three metal partitions between which the coils for the two or three bands are mounted. Holding the partitions together is the wave-change switch,

usually in the centre. Some units have side-plates, making the whole thing into a box, without top or bottom, and divided in the centre by the middle partition. When the unit is mounted on a chassis, the latter forms the top of the box, leaving only the bottom uncovered. What is the situation with respect to using such a unit with single-ended valves? With

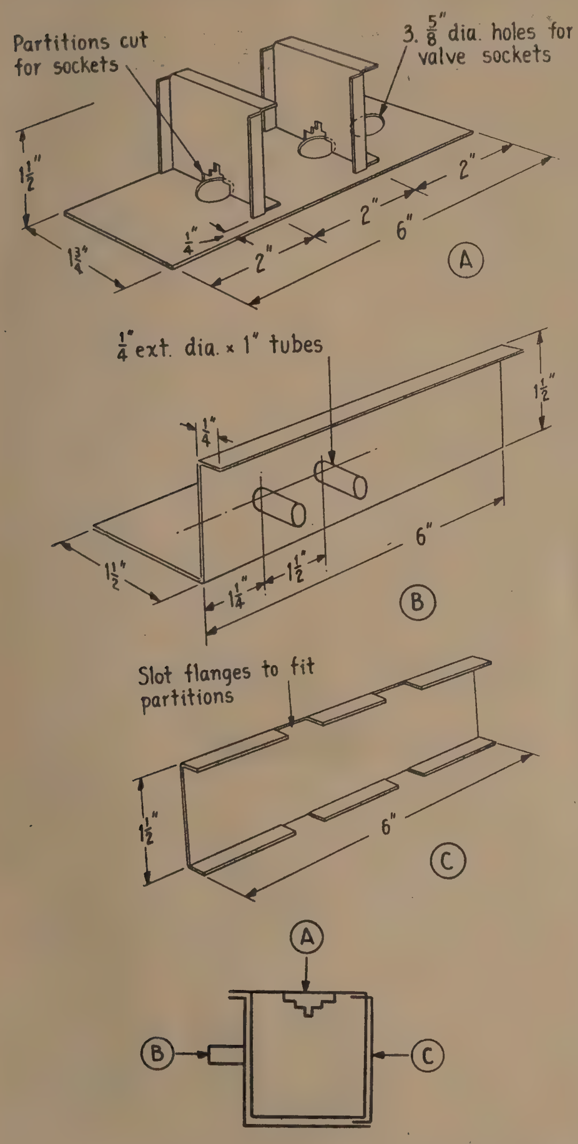

Fig. 1. Showing the three main parts (A), (B) and (C) for a valve unit suitable for miniature valves. The fourth drawing (at the bottom) shows how the three parts are fitted together.

an R.F. stage using a 6K7, EF39, or similar valve with a top-cap grid, the valve can be mounted with its base either in or opposite the compartment which houses the tuned circuit which connects to the grid of the converter stage. A short lead is thus secured between the plate of the R.F. amplifier and the R.F. coupling transformer. At the same time, the grid of the R.F. stage is above the chassis, away from the plate circuit, and with a short lead to the section of the gang condenser which tunes the grid circuit.

Now, if an attempt is made to use a single-ended R.F. amplifier tube, it is found that there is literally nowhere to mount the socket without putting either the plate-pin of the valve near to the tuned grid circuit components, or the grid pin near to the plate circuit parts. There is only one way out of the difficulty, and that is to mount the R.F. tube's socket exactly over one of the shield partitions, so that the grid pin comes in the compartment which holds the aerial circuit, and the plate pin on the opposite side of the partition, is inside the compartment which contains the R.F. coupling coil. This appears to be an ideal solution, and in cases where the coil unit is being constructed specially for single-ended valves, can be used with advantage, but where it is a case of using an existing coil unit, it means that a certain amount of carving will have to be done on the shields of the coil-unit, and this is not always either easy or convenient, since the units are not put together with a view to ease of dismantling! In this event, there is only one thing left to do, and that is to provide additional shielding, designed expressly for the valves, and independent, as far as possible, of that provided by the coil unit for the coils themselves.

CONSTRUCTION OF A VALVE UNIT

Since the coils are mounted together in a compact unit, then why not have a similar unit which contains the valves and their associated small parts? This, for want of a better term, could be called a "valve unit," and a suitable design is shown in Fig. 1.

The unit consists of a small box, 1½ in. square by 6 in. long, and has been illustrated for the case where an R.F. stage, a mixer, and a separate oscillator are to be used. Suggested dimensions are given, but there has been no attempt to lay down these rigidly, as the exact dimensions can be made to suit the types of valve being used. Fig. 1 (a), at the top, shows that the basic structure is the flat plate which has the valve socket holes in it, together with two partitions moued across the R.F. and mixer sockets. The most important of these is that across the R.F. tube socket. There is a slot cut in the partition to allow the socket to be inserted, and this slot is made to fit the cross-section of the socket used, as closely as possible. The tube is then mounted so that the partition cuts diametrically across the socket, missing the four pins between which it passes, and making snug contact with the tubular shield. By turning the socket in the appropriate direction before drilling the mounting holes, one can arrange matters so that the grid pin of the R.F. amplifier falls inside the front compartment and the plate pin inside the middle one. The mixer socket is mounted similarly, so that the signal-grid comes in the middle compartment. The plate of the mixer tube can come in either the back or the middle compartment, since this electrode does not carry appreciable voltage at signal frequency, and so cannot readily cause the tube to oscillate at signal frequency. It is best, however, to have it in the rear compartment, because some mixers may develop enough voltage at I.F. for it to be dangerous to have the signal grid in the same box as the plate. In the case illustrated, it will be noticed that there is no cross-socket shield provided for the oscillator

tube. This is quite unnecessary, as such a shield would serve no useful purpose.

When an oscillator-mixer type of tube is used, the oscillator socket hole will not be needed. Instead, the converter socket is so oriented that the oscillator grid and plate pins come in the rear compartment, and the signal grid pin in the middle one.

An important point about the dimensions of the part A in the diagram is that it should be so proportioned that the cross-socket shields are the same distance apart as the shield partitions of the coil unit with which the valve unit is to be used. In this way, when the valve unit is wired up and the covers are put on, it may be mounted on the chassis alongside the coil unit, and as close to it as possible, with the partitions in the valve unit level with those in the coil unit. The reason for this arrangement is readily seen when the remainder of the drawings are examined. Part (B) forms one side and the bottom of the valve unit. On the side of this part can be seen two tubes, evenly spaced about the R.F. shield partition, and projecting outwards. Part (C) completes the box, forming the other side. There are no ends. The bottom drawing shows how the three parts of the unit are fitted together, and represents a front elevation. Examination of the drawings will show that the two tubes mounted on the side of the unit come in on either side of the R.F. cross-socket partition. Thus, the front one is used to take the lead from the grid pin of the R.F. valve to the appropriate point in the coil unit, while the back one carries the lead to the R.F. valve plate. The whole construction can be seen to ensure that the completest possible shielding is made between the grid and plate circuit wiring of the R.F. stage. The unit is mounted, as stated above, right beside the coil unit, with the result that the ¼ in. tubes carrying the "hot" leads from the R.F. stage project well inside the coil unit, and these leads become unshielded only where this is very unlikely to cause coupling between them.

OTHER LEADS

Of course, there must be other leads which go to the valve unit, and most important among these are the mixer grid lead and the oscillator grid and plate leads. The former has to go into the same compartment as the R.F. plate lead, so that there is no point in shielding it from this one, and, at the same time, it is hardly near enough to the R.F. grid lead to warrant placing it in another piece of tubing. It can therefore come directly out of the valve unit, about half an inch from the tube carrying the R.F. plate lead. Similarly, the oscillator leads can come straight out of the rear compartment into the back section of the coil unit. The I.F. output lead, which is the same thing as the mixer plate lead, can come out of the middle compartment in unshielded wire, on the opposite side to that which has the R.F. leads. The first I.F. transformer can then be mounted on the chassis in the usual way, as close to the valve unit as desired, so that the mixer plate lead can easily be kept short. The only other leads to come out of the valve unit are those carrying the heater supply for the valves inside, and an H.T. lead for the mixer and R.F. stage screen feeds. The H.T. supply for the oscillator and the other plates will come in automatically from the coil unit.

OTHER USES

A valve unit such as the one described need not be used solely for attachment to a commercial coil unit, as its construction is admirably suited for use with separate coils, either shielded or unshielded, for a single band or for a number of bands. In these cases, all that is necessary is to mount the coils in a row alongside the valve unit, and spaced at suitable intervals, with straight shield partitions mounted on the chassis opposite the ones inside the valve unit. These will shield the wiring of the coils from each other in the same way as the partitions in a ready-made coil unit.

OTHER THAN MINIATURE VALVES

Although our illustration has used miniature valves, there is no reason why the same basic system cannot be used with Rimlock valves, or even with ordinary single-ended metal ones. The unit need be only 1½ in. square for the Rimlocks, as for the miniatures, but would need to be somewhat larger for the full-sized valves. The length from back to front can always be altered to suit the particular conditions to be met. The scheme is therefore very flexible, and is applicable to a large number of problems. It could easily be modified, too, to suit the case of a multi-stage I.F. amplifier, simply by allowing a little more room lengthways, to accommodate the I.F. transformers.

PARTS MOUNTED INSIDE THE UNIT

So far we have said nothing about the mounting of the small parts associated with the R.F. mixer, and oscillator stages. In the experimental unit built in our laboratory, the following components were placed inside the unit: The R.F. stage cathode resistor and bypass condenser, the R.F. stage screen dropping resistor, the mixer cathode resistor (an infinite impedance mixer was used), the coupling condenser from the oscillator to the mixer cathode, and the oscillator grid condenser and grid leak. There was found to be ample room inside the compartments for the components, and they were mounted on terminal strips and directly to the valve sockets where possible. The R.F. stage used a 6BA6, the idea being that if the arrangement was stable with a high mutual-conductance tube such as this, there would not be much likelihood of trouble with valves having an average Gm.

The remaining components associated with the three valves in the unit are either wired on outside the unit, or else are already in existence in the coil unit. For example, the A.V.C. bypass condenser in the R.F. stage grid circuit is an integral part of the coil unit, as is the bypass condenser at the "cold" end of the oscillator plate winding. Thus, there is no point in attempting to put the A.V.C. or plate decoupling resistors inside the valve unit. In fact, the coil unit completes the circuits of the R.F. grid and plate, the oscillator grid and plate, and the mixer grid. The mixer plate circuit is completed outside the unit by the primary of the first I.F. transformer. At the frequencies (up to 20 mc/sec.) usually covered by commercial coil units, there is no necessity to add such refinements as bypassing or decoupling the heater leads, so these are simply brought straight out of the valve unit.

EARTHING

It should not be assumed that once a valve unit such as this has been constructed, there is no possibility at all of the "front end" of the receiver giving trouble. All that such a unit can be expected to do is to minimize some of the commoner and more obvious feedbacks that can occur if the shielding is not good enough. It should be remembered that no coil unit is completely shielded in itself, and that it is therefore still a potential source of trouble unless proper precautions are taken. For example, the complete R.F. unit consists of (a) the coil unit, (b) the valve unit, and (c) the gang condenser. Thus, when the three are wired together, all of them must be interconnected by suitable earth connections. In this respect it should be remembered that it is most important to see that both the coil and valve units are firmly earthed to the chassis. Similarly, it is just as important to see that the gang condenser is properly earthed. The proper way to do this is to connect the wipers, by as direct a route as may be, to the earth connections on the coil unit. The latter usually has an earth wire in each compartment, to which the common ends of the grid coils are connected. Also attached to this point is a piece of tinned braid, which is intended to be taken to the wipers of the gang condenser. Sometimes, however, it is not possible to use these pieces of braid and at the same time to keep the leads reasonably short. If this is the case, it is advisable to remove the braid and solder one end of each piece to a point on the earth wire in each section of the unit, so that the brain can come through a hole in the chassis immediately below the wiper to which it will connect. If this is done carefully when the units are being mounted on the chassis, there should be no trouble. If the valve unit has been painted, some should be scraped off to ensure that the unit makes good contact with the chassis. Decoupling resistors in the A.V.C. and plate circuits should be wired as close as possible to their bypass condensers, after which the decoupled leads may run anywhere on the chassis without special precaution.

MATERIAL FOR THE VALVE UNIT

The best material to use for the valve unit is light sheet copper. Copper is by far the best metal to use for shielding on account of its low resistance, which makes it many times more effective than iron or steel. It is also easy to work, and is quite strong enough for a valve unit, even when quite thin. It has the further advantage of being able to be soldered. Aluminium, though easy to work and although it is the next best metal to copper from the shielding point of view, cannot be soldered, so that copper must be used at least for the part which carries the shielding tubes for the R.F. stage plate and grid leads. It is not good practice to use a mixture of copper and aluminium, however, because the latter metal develops a surface skin of oxide (quite invisible), which sometimes prevents good electrical contact between the various parts of the unit.

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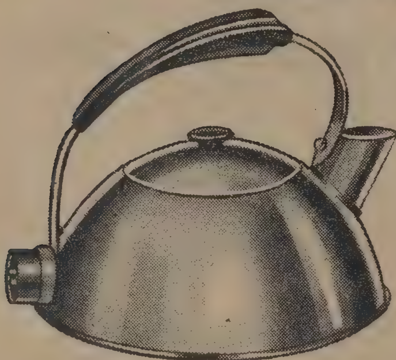

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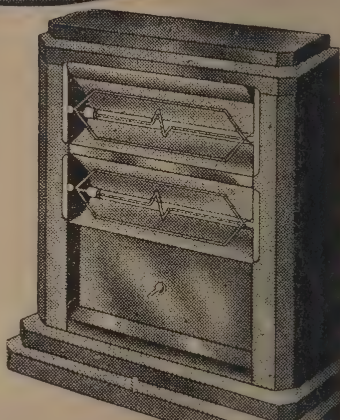

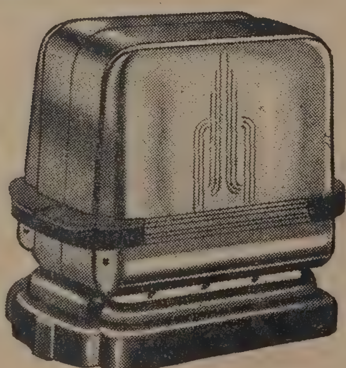

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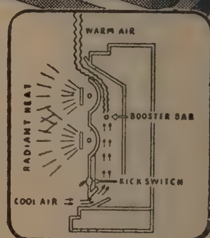

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AUDIO EQUIPMENT AND DESIGN:

Separate low and high frequency loud-speakers. Use of parallel-connected constant resistance dividing network to separate low and high frequencies into two bands for appropriate speaker. Chart for calculating values of L and C for network.
—**Electronics (U.S.A.), Feb., 1948, p. 124.**

Description and construction of high-quality record-reproduce amplifier. Push-pull 6L6's in power stage, with degenerative feedback.—**Radio News (U.S.A.), Jan., 1948, p. 54.**

Home inter-communication system with talk-back provision. Design and constructional details.
—**Radio News (U.S.A.), Jan., 1948, p. 63.**

Magnetic tape recorder. Constructional details.
—**Radio News (U.S.A.), Feb., 1948, p. 39.**

Magnetic tape recording systems. Description of "Brush Sound-mirror."—**Radio News (U.S.A.), Feb., 1948, p. 46.**

Magnetic tape recorders. Discussion of mechanical and electrical requirements.—**Radio News (U.S.A.), Feb., 1948, p. 56.**

Magnetic wire recorders. Explanation of function of components of typical recorder.—**Radio News (U.S.A.), Feb., 1948., p. 43.**

Magnetic wire recorder. Design of a basic amplifier for.
—**Radio News (U.S.A.), Feb., 1948, p. 44.**

Magnetic recording. Basic principles.
—**Radio News (U.S.A.), Feb., 1948, p. 52.**

Class AB1 modulator. Design and construction of compact resistance-coupled, high-gain amplifier driving high-power triodes. Improved quality.
—**Q.S.T. (U.S.A.), March, 1948, p. 13.**

ANTENNAE AND TRANSMISSION LINES:

Automatic Polar diagram recorder for testing radar antennae. One type of electromagnetic recorder modified for operation with microwave superheterodyne. Recorder operates with stylus.
—**Electronic Engineering (Eng.), Jan., 1948, p. 17.**

Rotary beam for 28 Mc. Features claimed: good back-to-front ratio, low vertical radiation, ease of manufacture and installation. Series condenser tuning of parasitic elements.
—**Radio News (U.S.A.), Jan., 1948, p. 44.**

Electronic switching for antennae, using surplus (U.S.) T/R Radar tubes.—**Radio News (U.S.A.), Jan., 1948, p. 50.**

Use of triode valve in cathode-follower circuit to couple antenna array to receiver. Circuit designed to provide adequate gain from antenna over wide band of frequencies, with a limited beam width. Arrays intended for 44-88 Mc. and 175-216 Mc. U.S. television bands.
—**Communications (U.S.A.), Jan., 1948, p. 22.**

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—**Electronics (U.S.A.), Feb., 1948, p. 112.**

Vertical antenna used on 75m. phone band. Comparison between beam and quarter-wave vertical antennae. Details of construction.—**Q.S.T. (U.S.A.), Feb., 1948, p. 18.**

28 Mc. transmitting array, 10 elements, cage type radiator. Details of construction and operational results.
—**Q.S.T. (U.S.A.)., March, 1948, p. 48.**

Inductive coupling to rotary beams. Mathematical calculations.
—**Q.S.T. (U.S.A.), March, 1948, p. 43.**

Shorted stubs. Use of in matching transmission lines to antennae.—**Q.S.T. (U.S.A.), March, 1948, p. 31.**

CIRCUITS AND CIRCUIT ELEMENTS:

Dynamic noise suppression. Desirable characteristics and analysis of a circuit employing controlled reactance valves in high and low pass filter sections of amplifier. Bandwidth of signal is varied.—**Radio News (U.S.A.), Jan., 1948, p. 46.**

The cathode-follower. Part 1 of a series. Basic theory of the circuit. Includes new theorems and constructions.
—**Electronic Engineering (Eng.), Jan., 1948, p. 12.**

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—**Electronic Engineering (Eng.), Feb., 1948, p. 55.**

The cathode-follower. Part 3. Constructing exact c-f characteristics by numerical and geometric methods.
—**Electronic Engineering (Eng.), March, 1948, p. 92.**

Circuit-breaker for instrument protection. Sensitive device using gas triode in electromagnetic relay for protection of D.C. instruments against overload. Circuits and operation.
—**Electronic Engineering (Eng.), Jan., 1948, p. 26.**

Four-terminal networks. Simple method of calculating transient currents at input and output terminals. Equations for various filter networks, and their solution.
—**Wireless Engineer (Eng.), Jan., 1948, p. 11.**

Amplifiers and mixers at V.H.F. and U.H.F. Mathematical consideration of stage gain and noise for narrow and wide band conditions. Application of properties of noise figures for amplifiers and mixers to obtain reduction of noise figures.
Wireless Engineer (Eng.), Jan., 1948, p. 21.

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Low-frequency compensation for resistance-capacity coupled amplifiers required to pass very low frequencies. Mathematical analysis and practical circuits. Application—industrial vibration analysis, electrocardiography, etc.
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High-speed tracing of Arabic numerals on cathode-ray screen. C.R. tube triggered by high-speed electronic calculator. Display recorded on fast film. Description of numeroscope and circuits.
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—**Communications (U.S.A.), Feb., 1948, p. 18.**

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—**Electronic Engineering (Eng.), March, 1948, p. 84.**

Super-regenerative circuits. Discussion of possible application of war-time uses of super-regeneration to FM reception.
—**Electronics (U.S.A.), Feb., 1948, p. 81.**

Operating point of valve with cathode load. Method of finding exact operating conditions with known voltage applied to grid of cathode-follower.
—**Wireless Engineer (Eng.), Feb., 1948, p. 63.**

Interference measurement. Description of measuring equipment —bandpass amplifier for operation at fixed mid-band frequency of 5 Mc. Examination of effects of bandwidth on various types of interference.
—**Wireless Engineer (Eng.), Feb., 1948, p. 44.**

Interference measurement. Effect of receiver bandwidth. Concluding article.
—**Wireless Engineer (Eng.), March, 1948, p. 89.**

Reactance modulator theory. Frequency modulation. Mathematical treatment of conventional reactance modulator and cathode-driven modulator. Bridge circuit for measuring modulator impedance.—**Wireless Engineer (Eng.), March, 1948, p. 69.**

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Power supply design using selenium cell rectifiers in voltage quadrupler circuit, without necessity for transformer or rectifier valve. 650v. D.C. output with 115v. A.C. input when low current drain.—**Radio News (U.S.A.), March, 1948, p. 51.**

Experimental circuit designed to eliminate speech and retain music in radio programme reception. Based on difference between ratio of peak energy to average energy in speech and music reception, respectively. Practical circuit, sensitive to characteristic difference, used to operate relay for short-circuiting speaker voice coil when speech being received.
—**Radio News (U.S.A.), March, 1948, p. 60.**

Ripple with choke-input filters. Chart for pre-determination of ripple. Curves for 50 and 60 cycle, half-wave, full-wave, single and three-phase rectifiers.
—**Electronics (U.S.A.), March, 1948, p. 132.**

Stabilizing power supplies. H.T. supply stabilization improved by feeding a fraction of unstabilized supply into control system, in addition to a fraction of the stabilized supply, as is commonly done.
—**Electronic Engineering (Eng.), March, 1948, p. 96.**

A.V.C. amplifier. Design of amplifier which maintains comparatively constant output with large input variations. Additional amplifier stage to increase voltage before rectification. Separate supply for regulated negative bias. Application to r.f. or a.f.
—**Radio News (U.S.A.), April, 1948, p. 67.**

Communications-type superheterodyne receiver for amateur bands. Consideration of design of receiver, with total of 26 valves, incorporating double frequency conversion, 12-circuit bandpass I.F., audio bandpass, treble-bass control and other features—**Radio News (U.S.A.), April, 1948, p. 75.**

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Narrow-band FM. Simple 15-watt phone transmitter. Circuits and constructional details. V.F.O. for operation on amateur

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FM antennae patterns. Measurement of horizontal and vertical radiation patterns using microwave, scaled-down versions of multi-element arrays.
—**Communications (U.S.A.), Feb., 1948, p. 20.**

INDUSTRIAL APPLICATIONS:

The "Thermistor," sensitive control instrument using semi-conductor class of material, the electrical resistance of which varies with temperature changes. Brief account of device which has indicated industrial applications, such as voltage regulator, volume limiter, protective agent and time-delay instrument.
—**Radio News (U.S.A.), Jan., 1948, p. 49.**

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Two-way taxicab radio systems. Discussion of necessary equipment, channel and installation problems of FM system on U.S. 152-162 Mc. band.
—**Communications (U.S.A.), Feb., 1948, p. 8.**

Facsimile transmitter. Details of equipment used by one U.S. newspaper.—**Communications (U.S.A.), Feb., 1948, p. 12.**

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Operator J. Simplified explanation, with practical examples of its use in radio calculations.
—**Wireless World (Eng.), Feb., 1948, p. 68.**

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Reflection Klystrons: as local oscillators: electronic tuning. Theory to explain limited variations of frequency possible by change in negative potential applied to reflector electrode. Use for automatic frequency control of receivers.
—**Wireless Engineer (Eng.), Jan., 1948, p. 6.**

Transmitter-blocker cells (anti-transmitter reception switch). Resonant wave-guide device between receiver branch and magnetron. Presents, on reception, high impedance in series with magnetron branch of main guide and prevents reception loss. Theoretical principles in design of fixed-tuned T-B cells. Method for computing loss. Suggestions for increasing band-width of systems using cells. Part 1 of article.
—**Wireless Engineer (Eng.), Feb., 1948, p. 55.**

MEASUREMENTS AND TEST GEAR:

Bridge measurements. New technique for measuring impedance at high frequencies. Transformer substituted for orthodox arms (ratio) to produce low impedance arms with voltage ratio unaffected by heavy capacitative loads.
—**Electronic Engineering (Eng.), Jan., 1948, p. 28**

Precise measurement of aircraft speed in transonic and supersonic range. U.S. system using vertical beams from modified V.H.F. instrument-landing system. Recorder measures time of reception of signals from aircraft as it passes through beams 10 miles apart.—**Electronics (U.S.A.), Feb., 1948, p. 72.**

Three-inch oscilloscope. Design and construction. Thyratron time-base circuit.—**Q.S.T. (U.S.A.), Feb., 1948, p. 51.**

New WWV schedule, effective from Jan., 1948.
—**Q.S.T. (U.S.A.), March, 1948, p. 72.**

Frequency checker. Modified form of absorption wavemeter with capacitative or inductive coupling through co-axial lines to test-points. Band-switching, 400 Kc. to 30 Mc. in four bands. Uses crystal diode 1N34.
—**Radio News (U.S.A.), March, 1948, p. 42.**

New electro-acoustic transducer. Principle of operation discussed. Waves originated in location remote from ends of magneto-strictive or piezo-electric body in which they are propagated, with advantage that one wave propagates freely in body whilst other wave, launched from the end of the body, may be used to explore without interference. Practical applications: flaw detection in metals, measurement of thickness of slabs of concrete.
—**Electronic Engineering (Eng.), March, 1948, p. 74.**

Service test instrument providing signal-tracer, high-fidelity amplifier, variable D.C. output, and various heater voltages.
—**Radio News (U.S.A.), April, 1948, p. 54.**

PROPAGATION:

Field tests for Citizens' Band (U.S.) U.H.F. Record of coverage of two-way systems with different types of transmitter, receiver, and antenna.
—**Electronics (U.S.A.), Jan., 1948, p. 92.**

Suggestions for amateur checking and recording of ionospheric conditions in 25-60 mc. range.
—**QST (U.S.A.), Jan., 1948, p. 25.**

Propagation of radio waves at frequencies above 100 mc. Fresh information on mechanism of propagation. Condensation of new theory and data developed during last war. Part 1: One-way transmission.
—**Electronics (U.S.A.), Jan., 1948, p. 124.**

Part 2: Two-way propagation, surface reflections, atmospheric refraction.—**Electronics, Feb., 1948, p. 118.**

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28 mc. Converter using modified form of regenerative, grounded-grid r.f. amplifier, balanced input circuit from folded dipole and triode first detector.
—**Radio News (U.S.A.), Jan., 1948, p. 52.**

Single side-band suppressed carrier radio-telephony. Suggestions for improved reception of telephony by this system.
—**QST (U.S.A.), Jan., 1948, p. 16.**

FM tuner. Simple 2-valve, super-regenerative tuner for use with audio section of AM receiver. Designed for tunable range of 88-110 mc.
—**Radio News (U.S.A.), March, 1948, p. 46.**

Supersensitive V.H.F. receiver in which co-axial line substituted for coil-condenser combination in detector circuit to achieve improved sensitivity and selectivity.
—**QST (U.S.A.), March, 1948, p. 20.**

Cross-modulation or "cross-talk." Discussion on causes. Practical method of locating source using portable battery receiver, with loop antenna, as direction-finder.
—**Radio News (U.S.A.), April, 1948, p. 56.**

The Synchrodyne. Refinements and extensions of the new type of receiver developed by the British Post Office Research Station.—**Electronic Engineering (Eng.), Feb., 1948, p. 49.**

TELEVISION:

Elimination of local electrical interference effects in television receivers. Discussion of sources of interference and methods of elimination.—**Radio News (U.S.A.), Jan., 1948, p. 57.**

Image Orthicon cameras. Choice of lenses: discussion of factors influencing choice, with mathematical equations and graphical interpretation of same.
—**Communications (U.S.A.), Jan., 1948, p. 20.**

Television and FM transmission lines: details of materials, components, accessories, and methods used in installation of co-axial transmission lines.
—**Communications (U.S.A.), Jan., 1948, p. 20.**

Preferred types of cathode-ray and camera tubes. Prepared by R.C.A.—**Communications (U.S.A.), Jan., 1948, p. 26.**

Design trends in television transmitters. Discussion of practices adopted by three leading U.S. manufacturers with regard to modulation, side-band suppression, and power tube cooling.
—**Electronics (U.S.A.), Jan., 1948, p. 77.**

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Automatic frequency control. Theoretical operation in television receivers.—**Radio News (U.S.A.), March, 1948, p. 68.**

Interference traps for television receivers.
—**Radio News (U.S.A.), March, 1948, p. 70**

Modern television receivers. Analysis of various stages of factory-built receivers. Part 1 of a series: R.F. stages.
—**Radio News (U.S.A.), April, 1948, p. 58.**

Television oscilloscope. Design problems in construction oscilloscope for observation of complicated waveforms over a wide frequency range.
—**Radio News (U.S.A.), April, 1948, p. 64.**

TRANSMISSION AND TRANSMITTERS:

20 k.w. (c.w.) 15 k.w. (phone) transmitter, frequency range 2.85-22.5 mc. for international broadcast. Design details. Anode tuning circuit an integral assembly, comprising water jacket, tuning coil, and tuning capacitor, output coupling coil and accessory components. Continuously tunable over whole range.
—**Communications (U.S.A.), Jan., 1948, p. 10.**

Single side-band radio telephony. Features of system using single side-band suppressed carrier telephony.
—**QST (U.S.A.), Jan., 1948, p. 13.**

Buffer and final amplifier construction using unit assemblies.
—**QST (U.S.A.), Feb., 1948, p. 30.**

Grounded-grid technique applied to triode high-power amplifier at 50 mc.—**QST (U.S.A.), Feb., 1948, p. 44.**

Single side-band phone transmission. Calculating power input to comply with existing (U.S.) regulations.
—**QST (U.S.A.), March, 1948, p. 45.**

150-watt transmitter with final tank circuit to cover four amateur bands from 3.5 to 30 mc., without necessity for coil changing. Series and parallel arrangement of coils and ganged variable condensers.—**QST (U.S.A.), March, 1948, p. 59.**

VALVES:

Design and application notes on new V.H.P. valves. 5 kw. television water-cooled triode for use as grounded-grid amplifier (GL-9C24 G.E.). Miniature pentode, filament type, for mobile and emergency use. Maximum anode dissipation up to 5 watts, operable with full input up to 100 mc. (5618 RCA). Image Orthicon for use with artificial light has photocathode with practically no infra-red sensitivity, better resolution, and improved signal-to-noise ratio (5655 RCA).
—**Communications (U.S.A.), Jan., 1948, p. 26.**

Preferred types of amplifiers and oscillators. Maximum input power v. frequency. Prepared by RCA.
—**Communications (U.S.A.), Jan., 1948, p. 27.**

The Skiatron. Details of dark trace C.R. tube in which fluorescent screen is replaced by one consisting of alkali-halide crystals. Application; television reception or short-duration recording of electric signals.
—**Electronic Engineering (Eng.), Jan., 1948, p. 20.**

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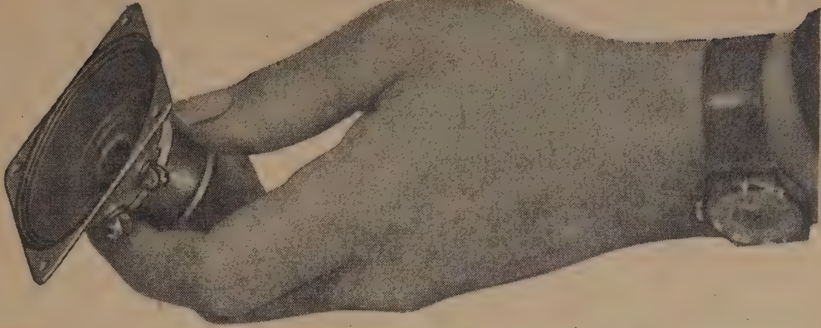

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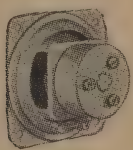

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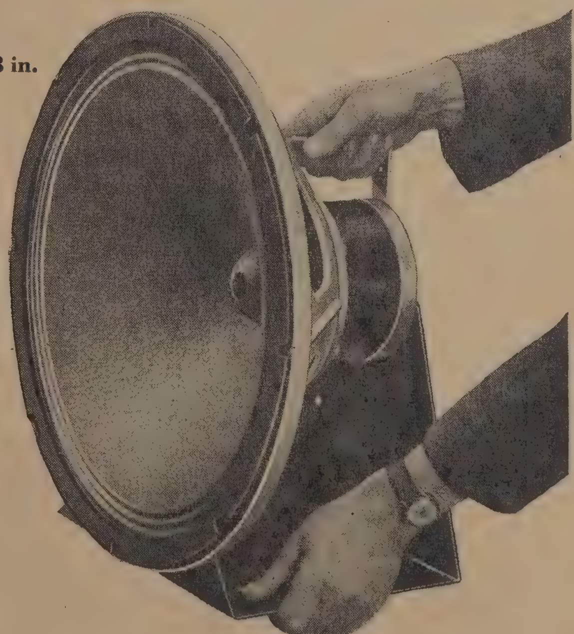

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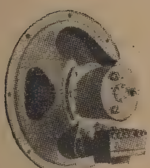
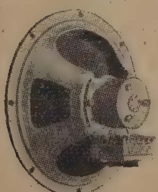
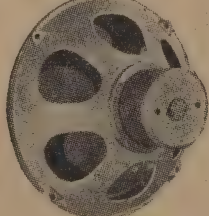


*Model P8D 8 in. diameter.



*Model P10G 10 in. diameter.



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* Supplied with attached transformers. All standard impedances.
Standard and special transformers available for use with other models.

QUESTIONS and ANSWERS

SPEAKER DIVIDING NETWORKS

R.J.C., Auckland, writes:—"I would be obliged if you could answer a few questions about the use of loud-speaker dividing networks. I propose using a 12" speaker for low frequencies, with a voice-coil impedance of 12 ohms, together with a 10", 2.3-ohm high-frequency unit.

"(1) Should I use a flat baffle or a vented enclosure for the high-frequency speaker?

"(2) For parallel or series-connected filter circuits, how are the values of the coils and condensers worked out? The only information I have seen works out the filter constants on the assumption that both speakers have the same voice-coil impedance.

"(3) If speakers of different impedances are used, would the apparent volume from the two differ, and if so, how can this be remedied?"

Replying to these questions in order:

(1) There is no point in using a vented baffle for the high-frequency speaker of a pair when they are used with a dividing network. This is because a vented baffle is designed for the case where the speaker has to reproduce frequencies down to and lower than the bass resonant frequency of the cone. In the case of a normal speaker handling frequencies only as low as 1500 c/sec. or so, this question does not arise. A small, flat baffle will suffice, though a short exponential horn would be better, since it would give more even distribution of the high frequencies through the room.

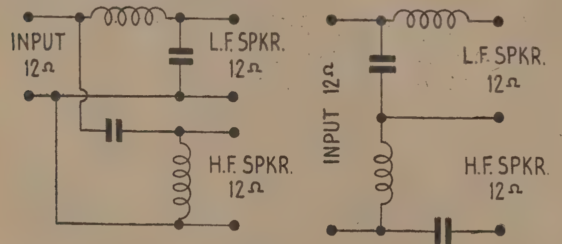

Fig. 1.

(2) As R.J.C. points out, practically all dividing networks are designed for speakers of equal voice-coil impedance. The figure 1 shows two simple networks that can be used, one of the parallel and the other of the series kind. Fig. 2 shows how the difference in speaker impedances can be allowed for. The scheme is simply to design the network assuming that both speakers have a voice-coil impedance equal to the speaker with the highest figure, in this case 12 ohms. Then, instead of connecting the other speaker directly to the network, a transformer is inserted at what would normally be the voice-coil terminals of the second speaker. This transformer must match the impedance for which the network was designed to the impedance of the second speaker. In our case, the network would be designed for speakers of 12 ohms impedance, and the transformer would have the correct turns ratio to match 12 ohms to 2.3 ohms. This extra transformer need not increase the cost of the whole system by very much, as even for high-fidelity results it can be quite small, and is not difficult to make because of the low impedances between which it works, and because the lowest frequency handled is quite high.

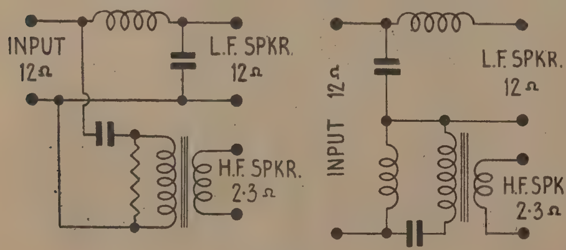

Fig. 2.

(3) If the speakers are properly matched, as suggested above, the question of equal apparent volume in their respective frequency ranges is not one of voice-coil impedance at all, but of sensitivity. Speakers which give approximately the same acoustic output for a given number of electrical watts input are required. If one speaker is much more sensitive than the other, the situation can be remedied only by placing a fixed attenuator in the circuit of the more sensitive speaker. This is undesirable, as the power consumed in the attenuator, if appreciable, represents a waste of audio power.

DESIGNING A SERIES-PEAKED VIDEO AMPLIFIER

M.A.MacL., Wanganui, writes: "In the January, 1947, issue of your magazine you give a series-peaked circuit for wide-band amplifiers. This is on page 29, Fig. 11. Could you please give me a few details of the calculation and formulae in designing this circuit for any particular case."

The design procedure is as follows. First of all, the valve to be used as the amplifier stage is chosen. If this is to be followed by a second stage, the following valve is chosen also. If not, as when the stage is to feed the plate of an oscilloscope, the shunt capacity of the output circuit must be found, or a suitable allowance estimated. The next step is to consult the valve handbook in order to find the values of C_0 and C_1 (the circuit is reproduced here for convenience' sake. Now let f be the frequency to which a flat response is required. Then the reactance of C_1 at the frequency f is $1/2\pi fC_1 = X_1$.

Now, let the ratio of C_1 to C_0 be equal to m. The values in ohms of X_1 and the value of m are now worked out.

Armed with these figures, we can now find the

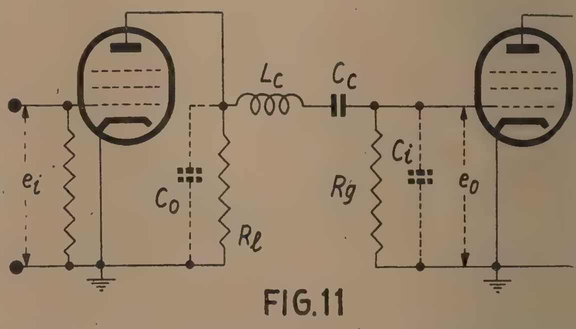

FIG.11

inductance of the peaking coil L_c, from the formula:

$$L_c = mX_o/4\pi f \text{ henries.}$$

Next, the value of the load resistor R_1 is found from the formula:

$$R_1 = X_0\, m/2 \text{ ohms.}$$

In working out these formulae, care must be taken to express capacities in farads, inductance in henries, resistance in ohms, and frequency in cycles/sec.

The values of C_c and R_g do not affect the design of the load resistor or the peaking coil. As long as stray wiring capacities are kept to a minimum, the above procedure will give good results, although after the stage has been built, it will probably be advantageous to make some slight alteration to the value of L_c. This can readily be found by experiment, taking a frequency response curve of the amplifier stage, and trying the effect of slight alterations in L_c.

CIRCUIT VALUES FOR A TONE-CONTROL SYSTEM

P.B.M., Hastings, writes that he is very interested in the circuit given as Fig. 13 in C. R. Leslie's article on tone-control systems. This article appeared in three parts, commencing with the March, 1948, issue of "Radio and Electronics." He asks whether we can supply suitable values for the circuit in question, as the original diagram did not include all the necessary component values. We are therefore re-printing the circuit here, together with a list of suggested component values. It should be realized that these have not been subject to experiment, and are given as a result of calculation and estimation only. However, they should make a satisfactory starting-point for those who are experimentally inclined, and should enable the value of the scheme to be assessed. The list of values follows.

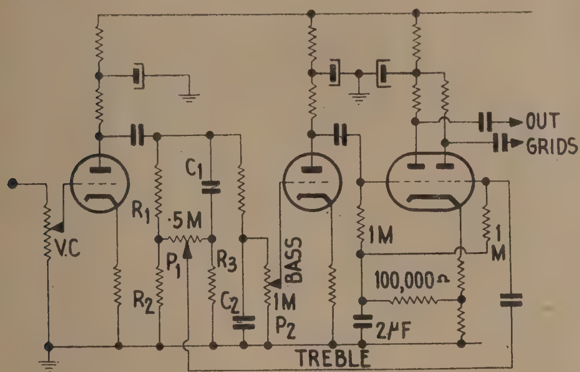

Fig. 13.

Calling the valves from left to right V_1 to V_3, we recommend that V_1 should be a 6J5, and V_3 a 6N7. Suggested component values are as follows:—

Vol. Control Pot., ½ meg.
Cathode Resistor, V_1, 500 ohms.
Plate Load Res., V_1, 100k.
Plate Decoupling Res., V_1, 50k.
Plate Decoupling Cond., V_1, 8 mfd.
Plate Coupling Cond., V_1, 0.1 mfd.
C_1, 0.0005 mfd.
R_1, R_3 1 meg.
R_2, 100k.
Unmarked Resistor joining C_1 and C_2, 100k.
Plate Load Resistor, V_2, 100k.

Cathode Resistor, V_2, 500 ohms.
C_2, 0.01 mfd.
Cathode Resistors, V_3, 50k. each.
Plate Load Resistors, V_3, 100k.
Plate Decoupling Resistors, V_2 and V_3, 50k.
Decoupling Condensers, V_2 and V_3, 8 mfd.
Coupling Condenser to left-hand grid of V_3, 0.1 mfd.
Coupling Cond. to right-hand grid of V_3, 0.01 mfd.

The components which control the width of the frequency bands passed by the bass and treble parts of the circuit are C_1 and C_2. The values of the resistors in the network control only the degree of boost attainable. If it is found that a middle band of frequencies, unaffected by controls, does not exist, this can be rectified by making either a small decrease in C_1, or a small increase in C_2, or both. It would be better not to rely on V_3 to fully swing the output valves, especially if these are triodes, but to follow V_3 with a low-gain push-pull resistance-coupled stage. This would ensure that there is no possibility of overloading the tone-control system before full output is reached.

AN IDEA FOR A HIGH-FIDELITY TUNER

The problems found in attempting to realize high audio quality from a broadcast band receiver are discussed, and a circuit is presented that will be new to a number of readers.

One of the bugbears of the almost universally used superheterodyne circuits is that in the simple form used in the majority of receivers, the selectivity is so high that the outer sidebands of the desired signal, which are the ones which carry the higher audio frequencies contained in the modulation, are too severely attenuated for really high-fidelity results to be obtained, however good the audio amplifier and loud-speaker system may be. If the response of the set as a whole is to include frequencies higher than 5000 cycles per second, the selectivity and overall gain must be reduced to the point where the former is unable to separate stations whose carrier frequencies are only 10 kc/sec. apart, and the latter is too low to enable distant stations to be received at all. In short, high audio quality and good selectivity and sensitivity are qualities in a receiver which, although they are all desirable, tend to be mutually exclusive. One time-honoured method of getting round the difficulty is the provision of variable selectivity. This can be a complete answer to the problem, since it allows high fidelity to be realized when listening to the strong local stations, and yet does not prevent the same set from receiving weak distant stations, and stations that are interfered with by others close to them in frequency. However, variable selectivity that is effective enough to allow the highest quality is a difficult and complicated matter to design, not to say a costly one, so that the scheme is either applicable only to the most expensive receivers, or else, to moderately priced ones, giving only a partial improvement. "Radio and Electronics" has under way the design of a receiver of the latter type, which, while costing only a little more than the conventional set, does give greatly improved reproduction of the higher audio frequencies, and will therefore be much better in this respect than the average receiver.

However, there are many who want even better results than can be got by a simple two-point variable selectivity system. Among them are to be found those who have gone to considerable trouble and expense to provide themselves with a high-quality audio and speaker system, and who are therefore used to hearing better results from their gramophone records than from the local radio stations. For these people a different approach to the problem is indicated. Another well-tried scheme is to use a tuner of low selectivity and sensitivity, capable of receiving only the local stations, and with enough band-width to accept the high-frequency sidebands that are transmitted. Even with the simplification that such a scheme allows, the problem of what kind of circuit to use is by no means cut and dried. There are those who favour a very simple T.R.F. circuit and will hear of nothing else, while others prefer a cut-down superhet. circuit with only a single I.F. transformer between the converter valve and the second detector. Let us examine some of the difficulties inherent in both schemes, and see which should be the better.

THE T.R.F. FOR HIGH-FIDELITY

This system has the virtue of the utmost in simplicity, and certainly has as much band-width as can be used—PROVIDED that the minimum of two tuned circuits track accurately with each other. At first sight, therefore, it would seem to be the ideal answer. But such is not the case, and for the following reasons: (1) Except on the strongest local signals, a T.R.F. consisting of a single stage of R.F. amplification and a detector does not provide a very strong signal at the input to the detector. This matters rather more than many people give it credit for, for reasons connected with the degree of distortion that can be tolerated in any system that is capable of reproducing very high audio frequencies. It is not a question so much of distortion produced by the R.F. stage itself, but of that introduced by the detector, whose performance in this respect is often overlooked. Now the only types of detector that can seriously be considered for this purpose are the diode, and the so-called infinite impedance detector. Some authorities consider that the latter gives less distortion than the diode; it is certainly more convenient to use where both sides of the input tuned circuit cannot be earthed. In any case, either is capable of excellent results, when properly applied. In the two last words are to be found a wealth of meaning. Both perform very well at high signal levels, and both require a reasonably large input signal if distortion is to be kept very low. This is because of the curvature of the detection characteristic at small input levels—a thing which cannot yet be avoided by any known system of detection.

For the above reason, the simple T.R.F. receiver is not as satisfactory as it might be under our conditions. This is because in the four main centres there are three to four local broadcast stations, of widely differing power, and located in such a way that at any given place there are apt to be wide differences between the signal-strengths received from them. Thus, in many instances, the high-powered station is some miles out of the city, as is 2YA in Wellington, while the subsidiary station, of much smaller power, is in the same place, as, for example, 2YC, which has only a twelfth the power of 2YA. At the same time, there are often two low-power stations in the city itself, so close to a large number of receivers that in spite of the smaller power, the signals from them are even stronger than those from the more distant powerful stations. Under these conditions, even a local receiver has to cope with a variety of signal strengths; it is imperative, then, if detector distortion is to be kept to a minimum, that the receiver has enough sensitivity to apply a signal of several volts to the detector from the weakest signal. This in turn means that some form of R.F. gain control must be used so that the strongest signals may not overload the R.F. amplifier stage, producing worse distortion than we set out to avoid. Using the single-stage T.R.F. with either manual or automatic gain control will not necessarily assist, because even with full gain, the sensitivity may not be great enough for the weakest station. In addition, so insensitive a set will not be susceptible to automatic gain control, so that we are left with a manual control, which is a nuisance, and the possibility of too little sensitivity on some stations.

It might appear at first sight that a satisfactory answer to this would be to build a T.R.F. receiver with more than one stage of R.F. amplification. This

should give greater sensitivity, and therefore be controllable by A.V.C., and at the same time retain enough band-width for high-fidelity performance. The answer to this is that even two stages of R.F. do not give enough gain for really satisfactory A.V.C., and in addition are actually rather difficult to build without losing the band-width one sets out to obtain. The reason for this unhappy state of affairs is the very real difficulty of rendering two stages of R.F. amplification absolutely stable.

In the average set, a small amount of regeneration does not matter very much as long as the set does not oscillate at any point on its tuning range, and as long as it does not sharpen the selectivity so much that the sideband cutting is noticeably worse than usual. In a T.R.F. intended for high-fidelity, however, much care must be expended in designing the lay-out of both parts and wiring if there is to be no regeneration. Anyone who may be under the impression that two stages of T.R.F. are only a little more difficult than one is mistaken. The requirement is not merely that the set should not oscillate, but that there must be no noticeable regeneration at all. If there is, the shape of the selectivity curve, which is what we are most interested in at present, may be anything but smooth and flat over the range of the sidebands. If it were a case of working at one frequency only, this could be adjusted by means of the three tuning controls, which in this event would be set only once and then left; but our receiver must be tunable over a band of frequencies, and should have as nearly the same selectivity curve as possible at all points on the dial. This is the difficult problem, and even if the set IS completely stable, **it cannot be solved by using any coils that are commercially manufactured.** Not only this, but the design of a set of inter-stage coupling units that would give this result is an exceedingly difficult and complex matter. This, incidentally, is one of the strongest technical reasons why the superhet. has been so fully developed and the T.R.F. has been left behind.

To summarize, the simple T.R.F. is unsatisfactory for our purpose because of its low sensitivity, and the difficulties which this introduces into the design of a high-quality local receiver, while the multi-stage article is so difficult to design (if it is to fulfil its purpose) that it may almost be regarded as impracticable. To those who may still doubt the truth of this statement, it is only necessary to point out that even where it is possible to have a high-fidelity receiving system built to order, the multi-stage T.R.F. is seldom or never adopted.

HIGH-FIDELITY ASPECTS OF THE SUPERHET.

As was mentioned above, a superheterodyne receiver with adequately designed variable selectivity can give a complete answer to the high-fidelity problem. However, this is not to say that such a receiver is easy to build, or that it has no difficulties attached to it. Let us examine it a little more closely, and see where the difficulties, and, if any, the disadvantages lie.

If the receiver is to be for local stations only, then the design is not at all a difficult matter. There is no need to worry about signal-to-noise ratio, or about really weak-signal performance in any way, because we can assume that for a superhet. any local signal will be a large one. Since extreme sensitivity is not needed, there will be no need for a stage of R.F. amplification, provided that the required sensitivity and selectivity characteristic can be obtained by suitably designing the I.F. stage or stages. If at the same time the I.F. section of the receiver can be made to have as much amplification as the conventional I.F. stage in an ordinary set, there will always be plenty of gain to provide a strong signal at the second detector, so that weak-signal detector distortion should be eliminated from the start. There should be enough gain to make A.V.C. applicable, thereby doing away with the necessity for a manual control. The main problem, therefore, is to secure enough band-width. This is readily accomplished by over-coupling the first I.F. transformer, so as to give it a double-humped response curve, with the peaks slightly closer together than twice the required band-width. This brings about a pronounced dip in the response at the carrier frequency, but this can be eliminated by using for the second I.F. transformer windings that are not over-coupled, and which have the appropriate Q in relation to that of the first transformer's windings. Since we are not interested in varying the selectivity to suit local or distant stations at will, there are none of the difficulties to be met that are associated with variable selectivity. By using I.F. transformers whose windings have high Q, the adjacent channel selectivity can be made high at the same time as the pass-band is widened, by the artifice mentioned.

Although the system just described is capable of very good results, when properly designed, the carrying out of the design, once it has been completed on paper, requires the use of instruments that are not usually available except in a properly equipped laboratory. Also, although there are on the market at least two types of I.F. transformer which provide two degrees of selectivity, it is not thought that these meet the specifications needed for high-fidelity reproduction although they certainly represent an advance on the standard I.F. transformer. It would appear, then, that for the amateur, and in fact anyone not equipped to adjust such a system properly, even the superhet. is not a practical proposition. However, there is a way out of the difficulty.

RAISING THE INTERMEDIATE FREQUENCY

The feature of ordinary I.F. transformers working in the 465 kc/sec. region which makes them unsuitable for high-fidelity reproduction unless some scheme like the one above is used, is that their Q has to be too high in ordinary circuits for them to have a wide enough pass-band. If it were possible to lower their Q and at the same time leave sufficient dynamic impedance for a stage still to have useful gain, then our problem would be solved. If the Q is lowered, as it easily can be, by shunting the windings with resistance, the Q is so low by the time that enough band-width has been attained that their dynamic impedance and adjacent channel selectivity as well are too low to be of any use. There is a simple formula relating the band-width, the frequency of operation and the Q of a tuned circuit, which makes it easy to illustrate the principle of what is to follow. It is:—

$$\Delta f = f/Q \quad . \quad . \quad . \quad (1)$$

where Δf is the **total** band-width, f is the centre frequency to which the tuned circuit is peaked, and Q is the Q of the circuit. The values of f and Δf can be in c/sec., kc/sec., or mc/sec. as long as each is expressed in the same units. For example, suppose we have a circuit tuned to 465 kc/sec., and that it has a Q of 100. The band-width is then $465/100 = 4.65$

kc/sec. Since this is **total** band-width, and by definition represents the band-width at which the response is 3 db. down, this means that the audio response is 3 db. down at 2,325 c/sec. Now this illustration is referred to the response of only one tuned circuit, and it is plain that if, as in practice, a set uses more tuned circuits at I.F. than this, the audio response will be still further attenuated at the high end.

Equation (1) shows that if we require a given band-width, we must do either of two things: we can hold the intermediate frequency constant and reduce Q, or else retain a high Q and raise the I.F. We have mentioned above the impracticability of the former course, so that it remains to be seen whether the second one has any insuperable disadvantages.

We will assume that the response is to be 3 db. down at a frequency of 10,000 c/sec., so that the total band-width will be 20 kc/sec. If we assume further that the Q of the circuit is to be 100, as before, then two of the three quantities in Equation (1) are fixed, and the third can be calculated. Thus we have: $20 = f/100$, so that $f = 20 \times 100 = 2{,}000$ kc/sec. Hence, if the I.F. is made 2,000 kc/sec., and only a single tuned circuit is used, with a Q of 100, the response would be as required. Of course, if the Q is less than this, the response would be better still. There appears to be only one difficulty here, and that is the fact that if a normal sort of I.F. stage is used, which has two double-tuned I.F. transformers, the selectivity would be considerably greater than that calculated for a single winding only. If the four circuits of the two transformers are assumed to add their selectivities directly (this is approximately true as long as there is no over-coupling), then there must not be more than $\frac{3}{4}$ db. drop attributable to each transformer, at a frequency of 10 kc/sec. on either side of resonance. From this, it can be seen that even at an I.F. of 2 mc/sec., the Q of the circuits must be less than 100.

It would therefore appear that the gain would still be two low, as was found to be the case when the Q of 465 kc/sec. I.F. windings is lowered. This is not necessarily so, however, since the gain of a stage depends not only on the Q of the circuit which is connected in the plate of the valve, but is also directly proportional to frequency. The gain is, in fact, proportional to R_d, the dynamic impedance of the circuit at resonance, and also to the mutual conductance of the amplifier valve. R_d is equal to $2\pi fLQ$, where f and Q have the same meanings as above. Thus, if Q is kept constant, and all that is done is to raise the operating frequency, the amplification of a stage increases in direct proportion to the frequency. This conclusion seems to be a direct contradiction of the well-known fact that high-frequency I.F. stages usually have much less gain per stage than those at lower frequencies. In practice it is not so, because it is impossible to keep the working Q at high I.F.'s up to the values attained at low frequencies. However, the conclusion does illustrate that the lowering of the Q to achieve band-width is in some measure compensated by the increase of intermediate frequency.

As far as selectivity is concerned, this will clearly be less than can be obtained in a specially designed 465 kc/sec. system which employs over-coupling to achieve the band-width, but this is not of extreme importance in a tuner intended only for local-station reception, for as long as it can separate the local stations without any sign of cross-talk, then the selectivity may be reckoned good enough.

ADDITIONAL FEATURES

If we examine the question of a high I.F. a little more closely, there appear some special features that are quite novel, and have some advantages. For instance, if we take the broadcast band as extending from 540 to 1,500 kc/sec., and have an I.F. of 2 mc/sec., the oscillator need only cover the range 2,540 to 3,500 kc/sec. Now the broadcast band itself, as quoted above, covers a frequency range of 2.77: 1, which needs a variable condenser of at least 300 mmfd. capacity variation. The oscillator, however, covers a range of only 1.38: 1. This is a much narrower band than has to be covered by either the signal or the oscillator circuits in a conventional receiver, and can easily be covered by a wide range of variable condensers. In fact, only a very small condenser would have to be used if the normal practice were followed of having as little minimum capacity as possible in the oscillator circuit. A variable condenser of 50 mmfd. maximum capacity will cover the required range quite easily, and furthermore needs about 100 mmfd. in parallel with it, to raise the minimum capacity to a value that just allows it to cover the right range. This means that the comparatively high-frequency local oscillator will have much better stability than if the smallest possible variable were used, in conjunction with no added capacity in parallel. A receiver which will tune over the whole broadcast band with only a 50 mmfd. condenser is indeed a novelty, and appears to have possibilities by way of reducing the space required for the tuner.

An obvious difficulty now appears, in that it would clearly be a difficult job to gang such an oscillator with the signal circuits, since the difference between the frequency ranges of these and the oscillator is so great that normal padding arrangements will not suffice. Also, it would be almost impossible to match the laws of the signal circuit and oscillator circuit variable condensers.

One way out of this difficulty that has much to recommend it is simply to omit altogether any tuning at signal frequency. In other words, the aerial would feed straight into the mixer grid circuit, and the job of selecting the desired station would be left entirely to the oscillator and the I.F. amplifier. One desirable effect of so doing is that the selectivity of the set is now ENTIRELY determined by that of the I.F. amplifier, so that if this is designed to pass the required band of frequencies for high-fidelity reception, there is nothing at all that can modify the performance in this respect.

If this is done, what will be the behaviour of the set in respect to image response? This question is easily settled, since the image frequencies will be, as usual, higher than the signal frequencies by twice the I.F. Since this has been assumed to be 2 mc/sec., the image frequencies will lie from 5,450 kc/sec. to 5,500 kc/sec. If, as suggested, there is no tuning in front of the mixer grid, the set will respond just as easily to image signals as to the desired signals, but unless the receiver is in such a locality that there are present in the aerial strong signals within this frequency range, no image response will ever be heard. In any case, if image trouble is apparent, there is another cure for it besides tuning the input.

With no input tuning, there are many more possibilities for spurious responses, and consequent whistles as the set is tuned than can be accounted for solely by image responses. The more important of these arise through harmonics of the oscillator

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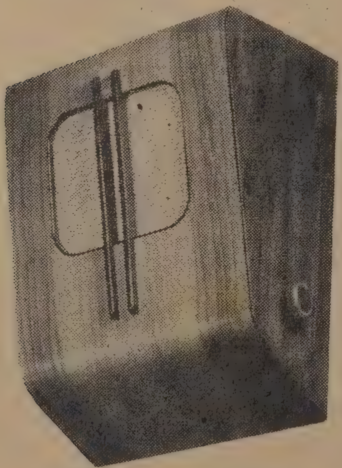

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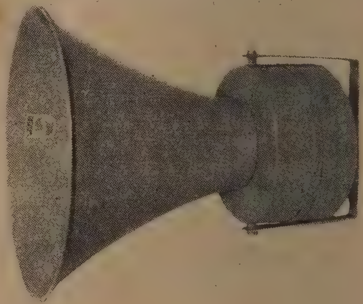

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Sound System keeps man- onstant and direct contact hout touring the works un- Instructions can be given and reports on progress received without the executive leaving his office chair.

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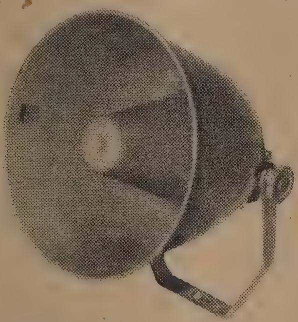
Modern streamlined Desk-stand Microphone, complete with press-to-talk switch. Ideal for general paging purposes.



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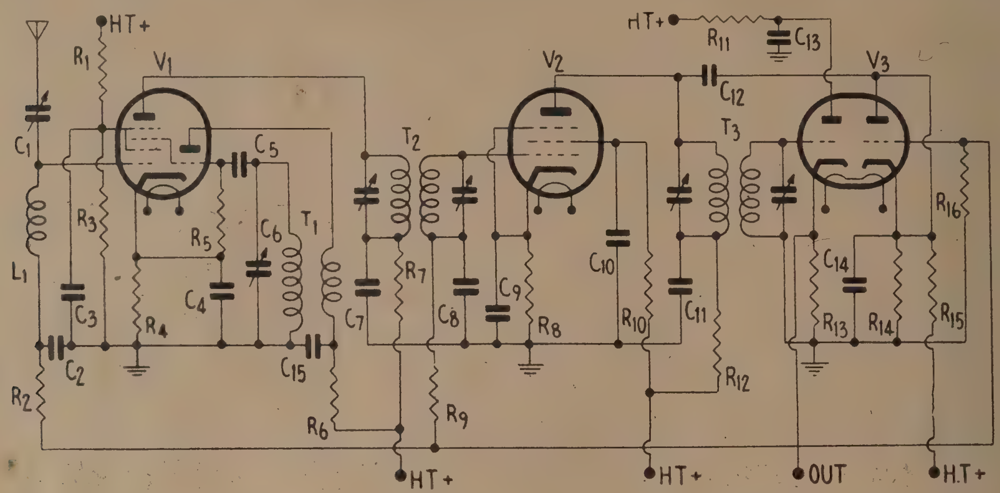
beating in the mixer with signals which have the appropriate frequency to give an output at the I.F. of 2 mc/sec. With an I.F. of this value, the second harmonic of the oscillator will cover a range of 5,080 to 7,000 kc/sec. This makes it possible for signals on the 3.5–4.0 mc/sec. amateur band to be heard when the set is tuned for broadcast frequencies between 750 and 1,000 kc/sec. Both this and image interference can be eliminated if, instead of tuning the detector was chosen in preference to a diode because of its low output impedance, which enables it to be directly connected to any amplifier without the use of a cathode-follower, and thereby simplifies the circuit without sacrificing anything in the way of performance.

Apart from the principle of using a high I.F., there is nothing unusual in the design of the tuner. On account of the high I.F., however, the by-passing and



input, a low-pass filter is placed between the aerial and the mixer-grid. In many cases, however, where there are few signals on either the 80m. amateur band or in the range 4,540 to 5,500 kc/sec., the low-pass filter will be found to be unnecessary.

PRACTICAL CIRCUIT EMBODYING THE ABOVE IDEAS

In Fig. 1 is given a practical circuit illustrating the use of the ideas put forward above. The circuit comprises an ECH35 oscillator-mixer, a 6SG7 I.F. amplifier, and a 6SN7, half of which is used as an infinite-impedance detector, and the other half as A.V.C. rectifier. The I.F. transformers are nominally 1,600 kc/sec., but can be tuned to any frequency between this and a little over 2 mc/sec. The I.F. amplifier could use a 6SK7, as long as appropriate changes are made to the bias and screen resistors, but the 6SG7 gives more gain, offsetting some of that lost by using a high I.F., and by the lack of tuning in the input circuit. A.V.C. is applied to both I.F. and mixer stages, and though it is not effective enough always to prevent the audio volume control from having to be re-set when tuning from one station to another when the differences in signal strength are very marked, it fulfils its main purpose, which is to allow a strong signal to be applied to the detector by all local stations, and at the same time to prevent the strongest ones from overloading the mixer stage. Also, there is enough A.V.C. action to prevent all possibility of "blasting" when tuning from a weaker to a stronger station. To assist in the chief purpose of allowing even a weak signal at the aerial to put a strong one into the second detector, a substantial delay of approximately 6v. has been provided for the A.V.C. diode. The infinite impedance

COMPONENT LIST

R_1, 25k. 1 watt
R_2, R_9, R_{13}, 100k.
R_3, R_{10}, 30k. 1 watt.
R_4, 350 ohms.
R_5, R_6, R_{11}, 50k.
R_7, R_{12}, 2k.
R_{14}, 7.5k.
R_8, 200 ohms.
R_{15}, 250k.
R_{16}, 1 meg.
C_1, 3–30 mmfd. pre-set.
C_2, C_4, C_7, C_8, C_9, C_{10}, C_{11}, 0.05 mfd.
C_5, C_{12}, 50 mmfd.
C_6, 50 mmfd. variable, in series with 3–30 mmfd. pre-set.
C_{13}, 8 mfd. 450v. electro.
C_3, C_{14}, C_{15}, 0.1 mfd.
V_1, ECH35.
V_2, 6SG7.
V_3, 6SN7.
T_1, osc. coil (see text).
T_2, T_3, I.F. transformers, 1.6–2.0 mc/sec.
L_1, 10 mH. R.F.C.
H.T., 250v.

decoupling has been made very complete, since in high gain circuits at frequencies of this order there is greater possibility than usual of stray coupling through un-bypassed leads, and through radiation from high-potential points on the circuit that cannot be bypassed, such as the plate pin on the I.F. valve.

OSCILLATOR CIRCUIT VALUES

There are available on the market at present variable-inductance oscillator coils, intended as replacements in sets when the original coil cannot be duplicated. The inductance is varied by adjusting an iron-dust core, and the one to be used is the one recommended for use in the intermediate short-wave range.

(To be continued.)

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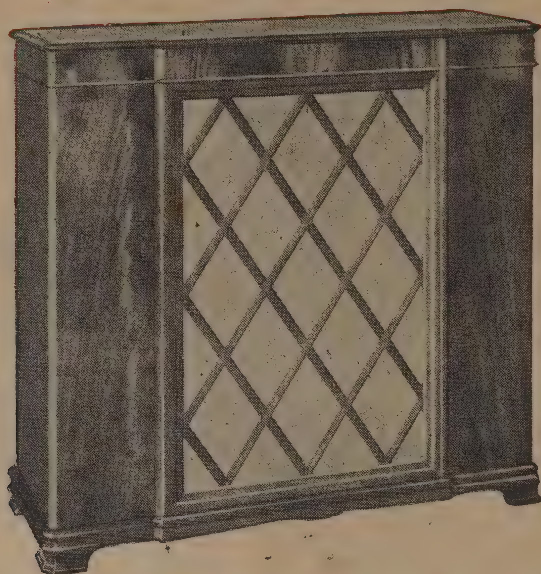

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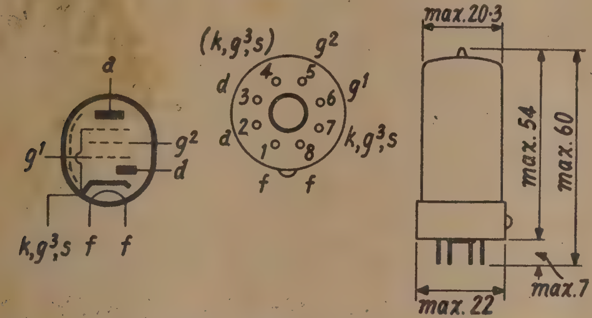
TUBE DATA

THE "RIMLOCK" EAF41 DIODE-R.F. PENTODE

The EAF41 is a variable-mu R.F. pentode combined with a single diode in the same envelope. The uses to which this tube can be put are very varied, as the pentode section can be employed as an audio amplifier, either pentode or triode-connected, an R.F. amplifier, an I.F. amplifier, or even a biased detector, while the diode can be used for either detection or A.V.C. rectification. If separate diodes are required for A.V.C. and audio detection, two EAF41's can be used in the receiver, one as I.F. amplifier and 2nd detector, and the other as 1st audio stage (either as triode or pentode) and A.V.C. rectifier. Characteristics and curves are given below.



Electrode arrangement, dimensions, and under-chassis socket diagram of the EAF41.

Operating Characteristics as R.F. or I.F. Amplifier:

Plate Voltage	250		volts.
Screen Dropping Resistor	95k.		ohms.
Cathode Resistor	300		ohms.
Grid Voltage	—2	—40	volts.
Plate Current	5	—	ma.
Screen Current	1.6	—	ma.
Mutual Conductance	1.8	0.018	ma./v.
Plate Resistance	1.2	10	megs.
Amplification Factor (g_1—g_2)	17	—	
Equivalent Noise Resistance	9000	—	ohms.

Heater and Capacities:

Heater—

Voltage	6.3 volts
Current	0.2 amps.

Capacities—

Grid-Plate Capacity	0.002 mmfd.
Output Capacity	7.0 mmfd.
Input Capacity	4.0 mmfd.
Grid-Heater Capacity	0.05 mmfd.

Operating Characteristics as Audio Amplifier (Pentode Connection):

Plate Supply Voltage	250 volts
Plate Load Resistor	200k. ohms
Screen Dropping Resistor	750k. ohms
Cathode Resistor	2700 ohms
Following Grid Resistor	0.75 megs.
Plate Current	0.58 ma.
Screen Current	0.2 ma.
Stage Gain	78 times
Total Distortion at 3v. R.M.S. Output	0.8%
Total Distortion at 5v. R.M.S. Output	1.1%
Total Distortion at 8v. R.M.S. Output	1.6%

Operating Characteristics as Audio Amplifier (Triode Connection):

Plate Supply Voltage	250 volts
Plate Load Resistor	100k. ohms
Cathode Resistor	1200 ohms
Plate Current	1.5 ma.
Stage Gain	15 times
Total Distortion at 3v. R.M.S. Output	1.2%
Total Distortion at 5v. R.M.S. Output	1.8%
Total Distortion at 8v. R.M.S. Output	3.4%

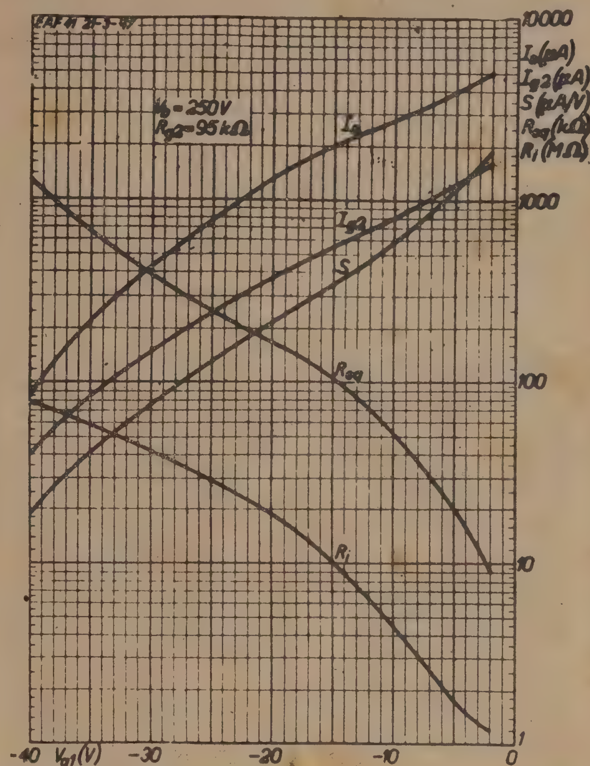
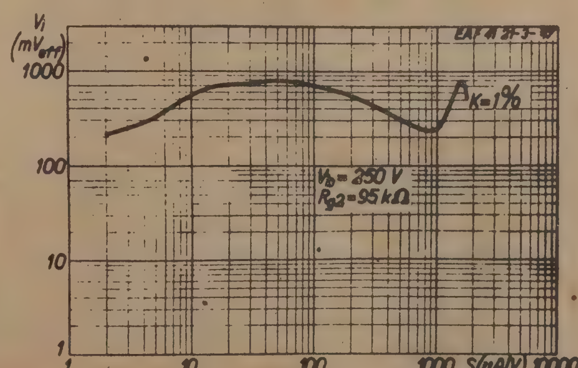
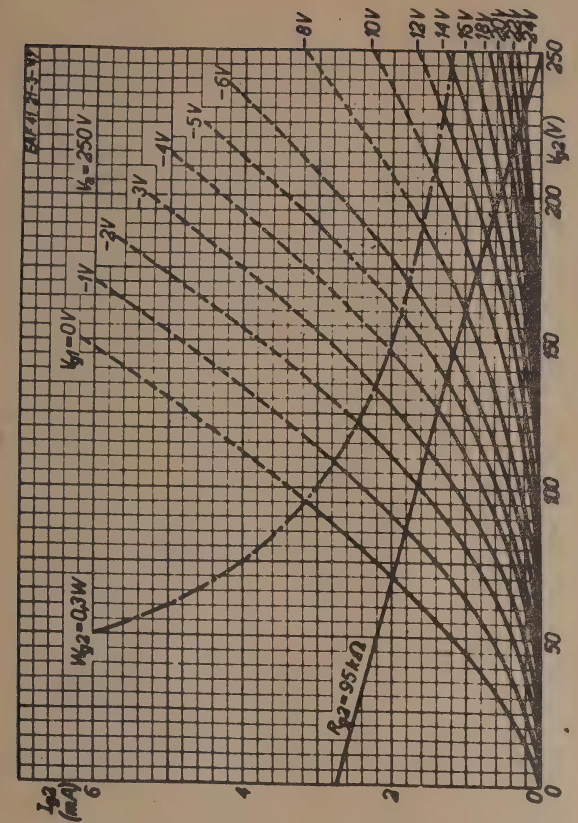


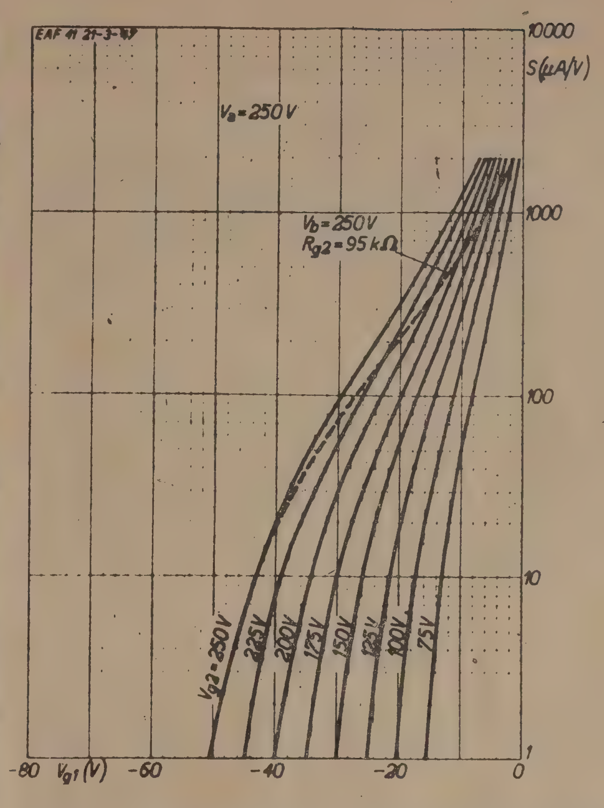
Plate current, screen current, mutual conductance, plate resistance and equivalent noise resistance versus negative signal-grid bias.



Input voltage, in millivolts, for a modulation distortion factor of 1%, versus mutual conductance.



Screen voltage—screen current characteristics, with load-line for a 95k. screen-dropping resistor. Also shown is the line for maximum screen dissipation of 0.3 watts.



Mutual conductance versus negative grid bias for various screen voltages. The dotted line shows the performance with a 95k. screen-dropping resistor.

The New Mullard Sub-Miniature Hearing-Aid Valves

The well-known British firm of Mullard has gone into production on a range of three sub-miniature valves, specially designed for the Government-sponsored hearing aids that will shortly be mass-produced. Abridged characteristics are given below, since although these tubes are as yet not available in this country, they will doubtless be imported at some time in the future, and information on special types is not always at hand just when it is wanted.

These valves are 10 mm. (0.4 in.) in diameter, the lengths being 30 mm. (1.16 in.) for the DF70, and 38 mm. (1.5 in.) for the DL71 and DL72 pentodes.

The extremely small size of these valves can be gauged from the fact that three DL70 voltage amplifying pentodes placed end to end approximate to the length of a cigarette.

CONSTRUCTION

The electrode structure is built up on a flat glass disc, in a manner basically similar to that employed in the well-known all-glass technique which has been perfected in England in the Mullard Laboratories. This method of construction ensures a high degree of rigidity and consequent freedom from microphony. The lead-out wires are tinned to facilitate soldered connection into the circuit.

FILAMENT RATINGS

Reference to the chart below will show that the filament current ratings of the Mullard sub-miniatures are extremely low. This advance will be apparent when it is considered that the three-stage amplifier in the hearing-aid consumes a total filament current of only 50 mA. as compared with 75 mA. for a similar circuit employing American sub-miniatures. This represents more than a 30 per cent. saving in current.

ANODE RATINGS

Taking into consideration the high performance obtained with the Mullard sub-miniatures, the anode current ratings are extremely low. The nominal anode voltage rating for the DF70 is 30 volts, whilst the voltage rating for the DL71 and DL72 is 45 volts.

The DL71 output pentode is intended for use with the hearing-aid circuit designed to work with a crystal earpiece of the insert type, and delivers a power output of 6 mW. at a distortion level of not more than 10 per cent. An alternative circuit is available for use with an external magnetic-type earpiece. This incorporates the higher-powered output pentode DL72. (Continued on page 47.)

A Practical Beginners' Course

PART 22

In the last instalment we discussed the reasons for incorporating bandspread in a shortwave receiver, and some of the ways of doing this. For beginners, the easiest form of electrical bandspread to apply was found to be the parallel system, since this can be added to any set, irrespective of its coil design, simply by placing a small variable condenser in parallel with the main tuning condenser, which now becomes the band-setting condenser.

As an example of this, we have shown a simple one-valve receiver using parallel bandspread, in Fig. 30. If this is examined, it is seen to be almost exactly the circuit of Fig. 28, to which a small bandspread condenser has been added. For the simplicity of the addition, the benefits are exceedingly great. No longer does the operator have almost literally to hold his breath while tuning in a short-wave station, so that when he takes his hand away from the tuning control, the signal may not disappear altogether. In fact, tuning is as easy as it is on the broadcast band. When, say, the 31-metre short-wave broadcast band has been found by tuning with the band setting condenser, this control is left set and the band explored with the bandspread condenser. Next month we will give a few more tips on how to make shortwave receivers easy to handle, like their broadcast band counterparts.

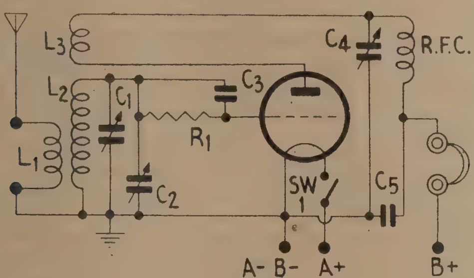


Fig. 30.

In this circuit, C_1 is the main tuning, or band-setting condenser, and C_2 is the bandspread condenser. This can have any value, according as more or less bandspread is wanted. A recommended value is one of about 10 mmfd. maximum capacity, as this will make tuning really easy at all parts of the dial. The same coils that were made for the set of Fig. 28 will do very well, since all the additional condenser does is to alter very slightly the range of frequencies covered by the set.

CONSTRUCTION OF SHORTWAVE RECEIVERS

By now, you will probably have noticed one very annoying feature of the sets we have so far described, especially when they are operating on the short waves. It is this: in addition to very close adjustment of the tuning condenser and reaction condenser, it is found that, when the hand is removed from the tuning dial, the tuning of the set alters enough to throw it off the station that was tuned in with some care. This effect is known as "hand capacity," as it is due to the hand on the control acting as a small condenser and changing the tuning of the set. When the hand is taken away, the hand capacity is removed, too, so that the set is no longer tuned to quite the same frequency as before the hand was taken away. There is a very simple cure for this fault, and this consists in building the set on a metal chassis instead of on a wooden base-board. If one does not want to rebuild the set completely in order to overcome the defect, it can be cured by covering the back of the front panel with thin metal sheet, such as copper foil. It is best, too, to cover the bottom of the base-board at the same time, using a single sheet of metal for both pieces, and connecting it to the earth side of the circuit. Another cause of hand-capacity is the leakage of R.F. currents into the headphone leads. This can be prevented by using an R.F. choke in series with the headphones, as in Fig. 30, and a small **bypass** condenser from the choke to earth. This is shown as C_5 in Fig. 30. It is called a bypass condenser because its purpose is to bypass radio frequency currents around the 'phones, preventing them from flowing through these. The choke should have a value of 2.5 millihenries, which is a standard value, and is satisfactory for all shortwave sets except those designed for very high or ultra-high frequencies.

If you are thinking of rebuilding the set in a metal chassis, this is not a difficult job, particularly if the chassis is made for you. The chassis for the set of Fig. 30 could be, say, 6 in. x 4 in., with a front panel bolted or welded to it along one of the 6 in. edges. The chassis should be 2 in. or more deep, which gives plenty of room for all the wiring to be placed underneath. Practically all components sold these days are insulated, especially for mounting on a metal chassis, so that there are no difficulties found in the wiring due to such things as the 'phone jack having to be specially mounted on a piece of insulating material. Of course, when a metal chassis is used, such things as Fahnstock clips can no longer be used, and properly insulated terminals have to be employed instead. Good terminals are quite expensive items, so that they are not often used by beginners. A good plan is to use a valve socket and plug instead of terminals. If an octal socket is used, this gives eight terminals at very low cost. Plugs, specially made to fit in valve sockets, are readily available, but one need not go to the expense of buying one of these if you can come by an old valve. The base is removed, and, by applying a hot soldering-iron to the pins and pulling the wires with a pair of pliers, these come out, enabling connecting wires to be soldered into the pins. A good plan, after the old wires have been removed, is to reheat each pin separately, and when the solder which sticks to the end is melted, the base is replaced in the mouth as quickly as possible, and a good hard blow forces the melted solder from the pin, leaving a clean hole through which to thread the new wire.

AUDIO AMPLIFICATION

So far, we have used valves only in one role—namely, as regenerative detectors. Nothing has been said about how to use a valve as an audio frequency amplifier, or as an amplifier for the radio frequency currents from the aerial before they are passed to the detector. Since R.F. amplifiers require a more advanced technique than audio amplifiers, we will now

go on to describe the basic working of a valve in this capacity, and show how an audio amplifying stage may be added to any of the one-valve sets we have made so far, converting them into two-valve sets, with more volume in the headphones than a single-valve set can give, and, in some cases, with greater ability to receive weak signals from distant stations.

Audio amplification, as its name implies, means the amplification of the audio frequency signal from the detector before it is applied to the instrument (either headphones or loudspeaker), whose job it is to convert the audio frequency currents into mechanical vibrations, and therefore into sound waves which our ears are able to detect. In operating a single-valve set, which consists only of a detector, it will often be noticed that a signal is received quite clearly, but at such small volume that the ear is unable to read the speech or distinguish the softer parts of the music. It is in cases like this that audio amplification pays handsomely, for it enables such signals to be read quite easily, simply by raising the volume in the headphones until the barely audible signal can be heard easily. If the radio frequency signal is so weak that the detector valve cannot deal with it effectively, then no amount of amplification after the detector will render the signal properly readable. This explains why we cannot receive any signal, however weak, just by adding more and more amplification at audio frequencies. It also explains why, for the best results obtainable, there must be amplification BEFORE the detector, at radio frequencies, as well as audio amplification. However, we will deal with only one thing at a time, and a simple detector followed by a reasonable amount of audio amplification can give vastly superior results compared with the same set without the extra amplifier. Also, although audio amplifiers are of many kinds, and in radio engineering form a specialized field of their own, they are one of the easiest types of amplifier to understand and to get going.

WHAT THE VALVE DOES

It will be remembered that the special usefulness of a triode valve is due to the fact that the grid, which to all intents and purposes draws no current from the source of voltage to which it is connected, is able to control relatively enormous quantities of plate current. In describing the action of a valve, and in using it as an amplifier, there are a number of new terms that need to be learned. Perhaps the most important of these is the MUTUAL CONDUCTANCE of the valve. This term represents a numerical way of saying how much control the grid exerts over the flow of plate current in the valve. It is expressed in a number of units, of which the easiest to understand is "milliamps per volt." This is usually abbreviated to "ma./v." It means that for a one-volt change in the potential of the grid, there will be so many milliamps change in plate current, if we assume that the plate voltage applied to the valve is kept constant. Thus, a valve whose mutual conductance is 2 ma./v., means one whose plate current changes by 2 ma. for every one-volt change in grid voltage. For other changes in grid voltage, the change in plate current will be in proportion. For example, if the grid voltage is changed by ½v., the plate current change will amount to 1 ma., or if the grid voltage is changed by 2v., the resultant change in plate current will be 4 ma.

Now, let us see what the mutual conductance means with respect to different types of valve, which have different mutual conductances. We have already used as an example a valve with a mutual conductance of 2 ma./v. Now, if we have another valve whose mutual conductance is 4 ma./v., this means that a given change in grid voltage of this new valve will produce exactly twice the plate current change that it would cause had it been applied to the first valve. Thus, the higher the mutual conductance of the valve, the greater effect do small changes of grid voltage have This is only another way of saying that the second valve will, under suitable conditions, give twice as much amplification as the first. It can therefore be seen that the term mutual conductance is a very important one when it comes to assessing the relative merits of different types of valve For ease of reference, the mutual conductance is usually written G_m, which is much shorter than the full name in words.

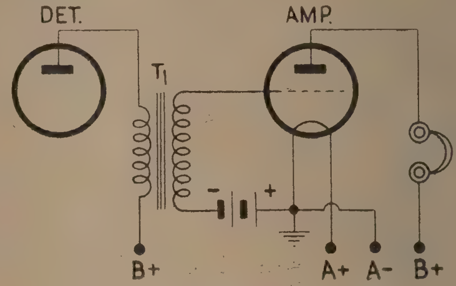


Fig. 31.

There are two other ways of expressing G_m that it is essential to know. The one already given is that normally used by British valve manufacturers, and found in their sheets of valve data. The Americans, however, use a unit called the MICRO-MHO. Instead of saying that a valve set has a G_m of so many ma./v., they say its G_m is so many **micromhos.** Although the names are so different, the things they refer to are identical, and there is a very simple relationship between the two units. For example, 1 ma./volt is exactly the same as 1000 micromhos. If this simple fact is known, it is quite easy to see how an American valve compares with a British one, just by converting both expressions for G_m into the same units. The situation is even more easily explained by saying that 1 micromho is the same thing as 1 MICROAMP. per volt. Since 1000 microamps = 1 milliamp, it is easily seen how it comes about that 1 ma./v. is the same thing as 1000 micromhos. For 1 ma./v. = 1000 microamps/v. = 1000 micromhos.

Having got so far, we are now in a position to examine the circuit of an audio amplifier and see how it works. The circuit is shown in Fig. 31. Here we have not drawn the complete detector circuit, because all we are interested in at the moment is the fact that this valve produces an audio frequency signal in its plate circuit. Now, instead of having the phones connected in series with the detector plate circuit, we have connected the primary winding of a **transformer.** This is a component that is new to us as far as audio frequencies are concerned, so perhaps it would be as well to say a few words about transformers first. Transformers are not altogether new to us, as we have used them already in our sets. In fact, the first crystal set to have a separate aerial coil in addition to the tuned circuit employed a trans-

former of a rather specialized kind. A transformer consists only of two coils of wire placed close together in such a way that, when a current of electricity flows through one of them, it causes a current to flow through the other. We cannot go into the question of just why this happens, in any detail, because a complete understanding of why a transformer works can only be gained by starting from "scratch" and giving a complete course on elementary magnetism and electricity. This explains, by the way, why such a course is essential for a complete understanding of radio. Without it, one can learn only WHAT circuits do, and not WHY they do it, which obviously represents an incomplete understanding of the subject of radio. Without a knowledge of the "whys" as well as the "whats," one can progress only so far. That is why in this course we have been at pains to give some sort of explanation, even if this is often incomplete, of how and why certain things occur, even if the course is intended to be practical rather than theoretical.

A transformer, then, consists basically of two coils of wire placed close together. If this is done, and an **alternating** current is made to flow through one of them, it will be found that a similar current will flow through the other, **even though there is no metallic connection between the coils.** The reason for this behaviour is to be found in a fact which establishes a connection between electricity and magnetism. It is this: a current of electricity flowing through a coil of wire makes the coil behave just as if it were a bar of magnetized steel, placed with its length in the direction of the axis of the coil. Now, it is a fact, and this can readily be demonstrated experimentally, that if a bar-magnet is suddenly brought close to a coil containing many turns of wire, a current of electricity will flow through the coil WHILE THE MAGNET IS MOVING. When the magnet stops, the current stops, too, and if the magnet is moved again, the current starts again, only to stop once more when the magnet has stopped again. Since a coil of wire with a current flowing through it behaves in a similar manner to a bar-magnet, the magnet in the above illustration can be replaced by a coil with a current from a battery flowing through it. As this second coil is moved up to or away from the original coil, a current will flow in the latter exactly as took place when the magnet was used. We now have something approaching our original definition of a transformer, but with one notable difference. This is that in our definition we specified ALTERNATING current, whereas in the illustration where the coil replaced the magnet, we have assumed DIRECT current to be flowing in it. Also, in a transformer, the two windings are usually fixed in position, and cannot be moved with respect to each other. In each case what has been said is strictly true, so that it now remains to reconcile the two different statements of the case.

This is not so difficult as might at first be imagined. The fact is, that actually moving a coil in which D.C. flows has the same effect on the second coil as leaving the first one stationary and passing A.C. through it. In both cases we have a **magnetic field** that is moving. In the case of the coil with alternating current passing through it, the magnetic effect of the coil reaches a maximum twice in every cycle of the current, and decays to zero twice in every cycle.

(To be continued.)

The PHILIPS Experimenter

Inserted by Philips Electrical Industries of New Zealand.

No. 9: USING THE EF39 AS A VOLUME-COMPRESSER STAGE

In these days of an overcrowded ether, not only on amateur transmitting bands, but almost everywhere else, too, it is more important than ever before for everyone responsible for emitting a radio frequency signal to pay more than passing attention to the reduction of interference. Nor is this solely a matter of evading the unwelcome attentions of controlling authorities. The latter realize to the full that spurious transmissions of any sort must be curtailed as far as possible, both by the enforcement of regulations and by the use of all available technical artifices which may remove interference at the source. Unfortunately, not all operators of transmitting equipment have the same realization—particularly amateur ones—and this almost always comes about through a laudable though misguided attempt to push their transmitters to their fullest modulation capabilities. There is still far too much interference to be heard from palpably overmodulated transmitters, and anything we can do to help remedy this state of affairs should be to the benefit of all concerned.

By all means let transmitters be modulated as fully as possible **as long as overmodulation is avoided,** because doing so tends to decrease rather than increase the amount of mutual interference, but if this is to be done, some form of modulation control is essential. Peak-limiting circuits are of great assistance in this respect, but have the disadvantage that if the speech level is consistently too high, the distortion becomes too great for intelligibility to remain good. The other main form of modulation control is a compresser circuit, which drastically reduces the gain of the audio system once a predetermined level has been reached. Such a circuit can be made to come into operation at any desired modulation level, and so can be made to meet the needs of any particular type of voice, or of any condition of extraneous noise. It cannot, however, ensure that the transmitter is never overmodulated, but it can reduce the possibility to a very large extent, and **in conjunction** with suitable peak-limiting circuits (which can be made faster-acting than the compresser) it can be said virtually to eliminate all possibility of such an occurrence. We have therefore devoted this issue of the Experimenter to presenting two practical circuits in which the EF39 can be used as a very effective volume compresser, and to a discussion of some of the finer points involved.

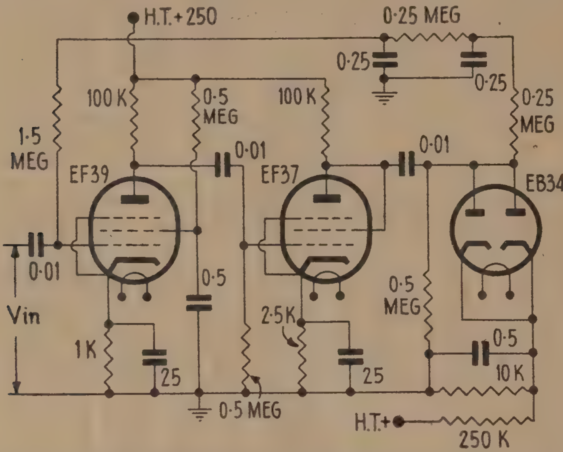


Fig. 1. Basic Compresser Circuit. The EF37 is used as a triode, and output may be taken via a coupling condenser either from the EF39 or EF37 plate.

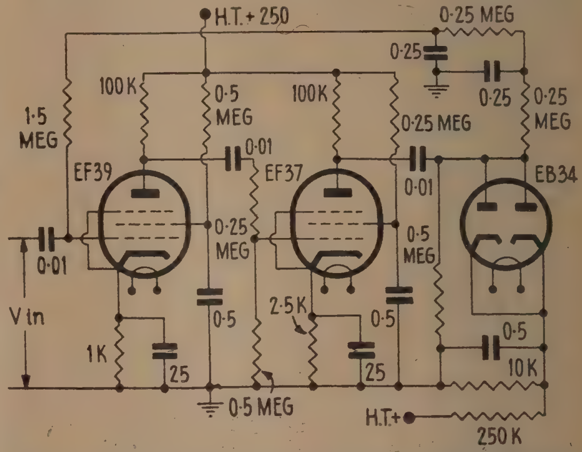


Fig. 2. This circuit has better compression characteristics than that of Fig. 1, owing to the higher gain of the EF37 when pentode-connected. With this circuit it is advisable to take the output from the EF39 plate.

PRINCIPLE OF OPERATION

There is not very much need to enlarge on this aspect of the circuits, since both make use of the now well-known principle, in which a variable-mu valve is used as one of the audio amplifier stages, and its gain is controlled by a D.C. grid bias, derived from the audio signal itself by means of a rectifier and smoothing system. The whole system has much in common with the ordinary A.V.C. circuits used in receivers, and is more allied to these than to the volume expander. In Fig. 1 is shown one suitable circuit, for which performance figures are given in Fig. 3. The first valve is an EF39, which is the controlled stage, and can well act as a microphone pre-amplifier, as in its uncontrolled state it has a gain of 85 times with the values illustrated. The second stage, an EF37 connected as a triode, provides further amplification, which is desirable in any event, and isolates the control rectifier, the EB34, from the controlled stage. The EB34 is used as a single diode by having its plates paralleled, and is connected as a shunt rectifier, exactly as are most normal A.V.C. rectifiers. The cathode of the rectifier is made several volts positive by means of the 250k. and 10k. voltage divider connected between H.T. and earth. This

positive voltage constitutes the delay voltage, which determines to what extent the audio output of the two amplifier stages can build up before the control action comes into play. It will be noted that the polarity of the control rectifier is such that a negative control voltage is developed at its plate, and after passing through the audio filter, is applied to the control-grid of the EF39. Thus, once the rectifier commences to function, any increase in output of the EF37 (and therefore of the EF39) causes a negative control voltage to appear at the grid of the latter, reducing its gain, and tending to keep the output level constant, irrespective of further increases in the audio voltage applied to the input. In Fig. 2, we have an almost exactly similar system, the main difference being that here there is more gain between the controlled valve and the rectifier, since the EF37 is now connected as a pentode. We will discuss this point later in connection with the operation of the compresser circuit.

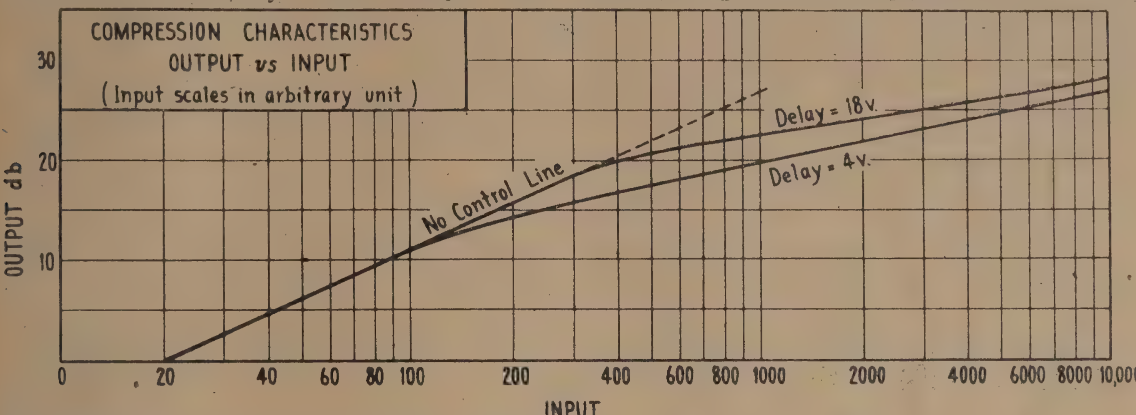


Fig. 3.

CIRCUIT DETAILS

The circuits of both Figs. 1 and 2 are quite straightforward, in that the EF39 and EF37 are operated under normal resistance-coupled conditions. There appears to be little reason for any possible changes in this part of either circuit, since it is only the rectifier circuit, once the audio gain has been established at a fixed figure by the amplifiers. In the EB34 circuit, the only value which needs to be altered to suit varying conditions is that of the cathode resistor. In the diagrams, this has been shown as 10,000 ohms, which in conjunction with the 250k. resistor from H.T. to cathode alters the delay voltage on the EB34, and therefore the point at which compression starts. The filter circuit which removes any residual audio frequencies from the control voltage is in two sections rather than the more usual single section. This is because if only a single section is used, the time-constant of the filter has to be made so long that the compression does not come into operation until an appreciable fraction of a second after the original increase of level which caused the control voltage to appear. Thus, if a single section filter were used, consisting of a 0.5 meg. resistor and a 0.5 mfd. condenser, the filtering action would not be so complete as if two sections, each consisting of a 0.25 meg. resistor and a 0.25 mfd. condenser, had been employed. At the same time, the former arrangement would have a longer time delay than the latter. The values shown on the diagram give a time-constant of approximately 0.125 secs. This is still too great to allow the compresser to act rapidly enough for an initiating burst of volume to be limited before it gets to the rest of the audio system. At first sight, therefore, it might appear that the unit would not be effective at all, but this is far from being the case, especially if peak-limiting circuits are used in conjunction with it. The peak-limiter ensures that the initial burst of level does not overmodulate the transmitter, after which the compresser

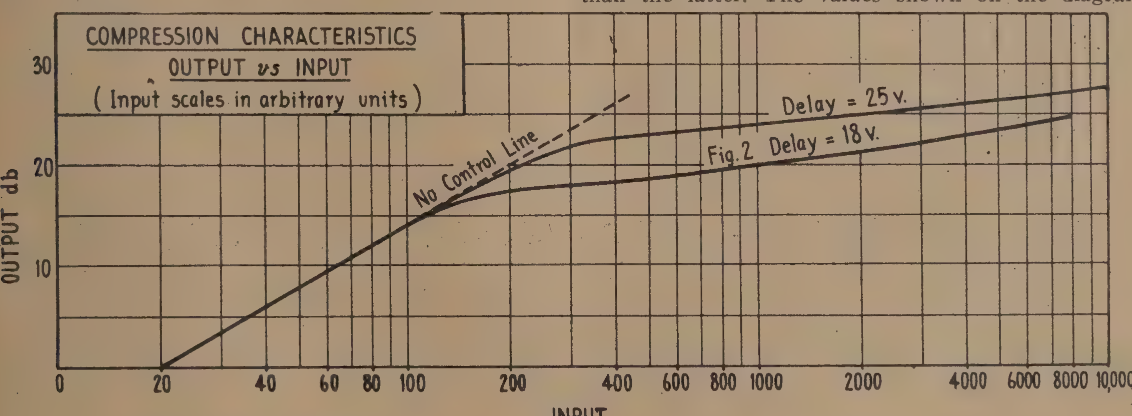


Fig. 4.

comes into action and prevents the succeeding audio peaks from reaching a level that is high enough to operate the peak-limiters. Thus, the distortion that would be caused by the limiters alone is eliminated, while there is still no possibility of overmodulation.

CHANGING THE DELAY VOLTAGE

Although the delay voltage has been shown fixed, there is no reason why individual constructors cannot make the delay variable by substituting for the 10k. resistor in the cathode circuit of the EB34 a potentiometer of, say, 100k., used as a rheostat. The control could then be brought out to the front panel of the speech amplifier, or else made pre-set after the best setting has been found.

HOW TO CONNECT THE COMPRESSER

Since the EF39 controlled stage has high gain, the compresser circuit can be used to replace the existing pre-amplifier stage, where a low-level microphone is used. In this case, output would be taken from the plate circuit of the EF39. An extra coupling condenser need not be used, as the grid of the following audio stage can simply be connected directly to that of the EF37, if the circuit of Fig. 1 is being used. If the circuit used is that of Fig. 2, the grid of the next stage can be connected to the top of the voltage divider in the EF37 grid circuit, as in this case, the latter tube is fed with only a portion of the total output of the EF39. It will be noted that on both circuit diagrams no output terminal has been indicated. This is because the output can be taken either from the EF39 or from the EF37, according to requirements. If the extra gain of the EF37 is desirable in the whole audio chain, its gain may be made use of. If not, output can be taken from the EF39, as suggested above. In either case, the compression characteristics will not be affected, since there is no gain control on the EF37. Which course is followed is merely a matter of convenience.

PREVENTION OF OVERLOADING

If a low-level microphone is used, there will be no possibility of overloading the EF39 controlled stage. Consequently, an input potentiometer need not be provided at the grid of this tube. However, if a high-

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BEACON TECHNICAL TOPICS

High Quality Audio Transformers

Where large power necessitates a number of similar speakers being employed, the best solution, and the one most frequently used, is to design the output transformer to suit the combined parallel impedance of all the speakers. For example, if there are four 15-ohm speakers in use, the secondary would be wound for 3.75 ohms.

In this case, when using fewer speakers, a 15-ohm resistance of suitable wattage rating should be switched in, to replace each speaker removed. The advantages of this scheme are:—

(a) Constant load is maintained on the tubes;

(b) The full amplifier output can never be accidentally fed into one speaker, thus ruining the suspension;

(c) Each speaker receives constant power;

(d) When fewer than the maximum number of speakers is used, the load phase angle is improved due to the added resistance. This lowers the distortion due to the speaker load being a reactive one. (See *Radiotronics*, No. 124, page 25.)

Whenever possible, the use of two transformers in cascade, such as plate-to-line and line-to-voice coil, should be avoided. This causes an additional power loss and unless the two transformers are both of *very* high quality, distortion will increase noticeably and the frequent response will fall off appreciably. It will become exceedingly difficult to achieve stability with an inverse feedback loop that includes both transformers due to the decrease in shunt inductance, and the increase in leakage inductance.

To meet the demand for output transformers possessing a wide frequency range with low distortion Beacon has produced the following standard line in three power ratings to meet all normal requirements. These are for use with push-pull triode amplifiers either with or without feedback and have a 15-ohm secondary. They are not supplied as general purpose multi-match units, another series being available to meet this need. Tetrodes and pentodes are not recommended where the highest quality performance from an amplifier is required. Information on loud-speaker dividing networks for use with these transformers will be presented next month.

P.P. Tubes as Triodes	Load Resistance Ohms	Transformer Rating Watts	No. Cat.
PX4	3,000	10	48 S 01
2A3	5,000	10	48 S 02
2A3	3,000	15	48 S 03
PX4 & EL37	4,000	15	48 S 04
PX25	5,000	15	48 S 05
KT66 & 807	10,000	15	48 S 06
EL37	4,000	20	48 S 07
DA30	9,000	20	48 S 08
PX25	10,000	20	48 S 09

IAN C. HANSEN.

level mike is used, an input control will be necessary, and should be placed in front of the 0.01 mfd. blocking condenser shown at the input. Otherwise, the control would short-circuit the control voltage from the EB34. If it is desired to take the output from the EF37 plate circuit, it will be necessary to check that the input is not great enough to overload this stage, even if the EF39 is not overloaded.

SETTING THE DELAY VOLTAGE

In order to see the effect of variations in (a) delay voltage and (b) the gain of the EF37 stage, the accompanying performance curves have been prepared. Fig. 3 refers to the circuit of Fig. 1, where the gain between the EF39 and the EB34 is approximately 15 times. Fig. 3 has been drawn also to show the effect of large and small delay voltages on the performance. It will be noted that the curve of input against output is a straight line up to the point where the control starts to function. Thereafter, the curve becomes flatter, indicating that the gain has been reduced. However, the output does not remain constant, but continues to rise even after the control starts. Two salient points are demonstrated by Fig. 3; first, when the delay voltage is small, the control starts at a low input voltage, and comes into play quite gradually. With a higher delay voltage, the transition from no-control to control is much sharper, and takes place at a higher output level. Secondly, the control is better with the high delay voltage, since the output rises more slowly after the control comes in than when a small delay is used.

Now, if Fig. 3 is compared with Fig. 4, it will be seen that with higher gain between the controlled amplifier and the rectifier, the performance is better again, in that the curve is still flatter after the control has come into action. Thus the two sets of curves demonstrate (a) that a large delay voltage is preferable and (b) that high gain between the EF39 and the EB34 is desirable. However, the degree of compression given by the circuit of Fig. 1 is quite adequate as long as a delay of ten volts or more is used.

When the compresser has been constructed and wired into the audio channel of the transmitter, two controls will determine at what percentage modulation the control will commence. One is the delay voltage on the EB34, and the other is the main gain control AFTER the compresser circuit. However, so as not to complicate matters, it is best to fix the delay voltage, and use only the latter control, as doing so ensures that a bad combination of the two cannot be used. It will be found that with the compresser in circuit, it is possible to have the average level into the modulators much higher than is the case without it, and still to avoid the overmodulation without having to regulate the voice carefully. The exact level at which the control should start cannot be specified, as this depends mostly on the characteristics of the voice in question. If one is given to sudden bursts of volume, much louder than the average speech level, it will clearly be necessary to start the compression at a lower modulation percentage than if the voice level is fairly constant. In this case, the "knee" of the curve can be placed at an output representing about 80 per cent. modulation, and this is done simply by turning up the main gain control until the normal voice level swings the modulation up to this figure on peaks, while at the same time it takes some extra-loud talking to operate a carrier-shift or other overmodulation indicator.

OTHER PRECAUTIONS

There are two things that need to be watched with these two circuits. The first of these is motor-boating. If this is encountered, it is easily cured by decreasing the size of the coupling condensers between the EF37 and the EB34, and between the EF39 and EF37. The trouble, if encountered, is due to the feedback at very low frequencies that takes place through the control circuit. Reducing the two condensers mentioned simply lowers the response of the control chain to frequencies of 10 c/sec. and below, at which feedback can be troublesome.

The second point is that the delay voltage should not be made higher than 25 volts or so. If it is, there is a danger of the maximum undistorted output voltage of the EF39 being reached BEFORE the control starts, with subsequent heavy distortion at all controlled levels.

OUR GOSSIP COLUMN

Mr. G. R. S. Allen, Export Manager for the Rola Company (Australia) Pty. Ltd., of Melbourne, has been in New Zealand discussing general activities with Swan Electric Co. Ltd., the manufacturers of Rola in New Zealand.

* * *

By the time this issue of "Radio and Electronics" appears, Norm Swann, Managing Director of Swan Electric, will have arrived back in New Zealand after a very fast trip through England and America. Brig. Mason has been deputizing for Norm during his absence.

* * *

Guy Thornton, who in the past has been Manager of The Grover Electrical Co. Ltd., has been appointed representative for Martin Burns and Co., Wellington. Messrs. Martin Burns are the Wellington territory agents for G. A. Wooller & Co. Ltd., Auckland, so we may confidently expect that Guy will be very active in the Wellington area.

* * *

Alex. Ayton, who has been with Radio Corporation of N.Z. Ltd., has now joined "Radio and Electronics" and is assisting Doug Foster in the lab.

* * *

George Wooller has been a recent visitor to Wellington. We were pleased to see him looking his usual dynamic self after his prolonged illness. George

was on a business trip, but by some odd prank of fate his visit coincided with the Foxton races!

* * *

Just as Ron Greenwood, Managing Director, was due to leave for the U.S.A., Mrs. Greenwood was taken seriously ill with pneumonia, so in spite of all the 'plane bookings having been made the trip was off. However, we are now happy to report that Mrs. Greenwood is now making a rapid recovery, and Ron will be leaving for the States in the near future.

* * *

Quite a number of changes have taken place in the staff of the National Carbon Pty. Ltd. Tom Jamieson has resigned from the company to enter into his father-in-law's business. All our best wishes, Tom! Maurice O'Sullivan is now in Head Office on general sales work. E. F. Marker has been appointed North Island field representative, and will be active in the territory shortly. Frank Hayhurst, South Island representative, is doing it well in a new Ford. Maurice O'Sullivan and George McLellan have each purchased a new section in Wadestown, and as a result, both have become accomplished architects.

* * *

On reading through the March issue of "QST," we noticed their column entitled "Twenty-five Years Ago." This extract therefrom should be of interest to readers:—

> "DX records continued to topple as March, 1923, 'QST' went to press. Latest confirmations have the signals of 6KA, 5PX, 6BCR, 9BED, 9UU, 9YAT, 6KU, 9AJP, 5XAD and 6EN heard in New Zealand by Mr. R. Slade, who was using a one-tube regenerative receiver."

As most Hams know, Ralph is still as enthusiastic as ever and is frequently heard on 40 and 80 metres.

Messrs. Benson, Wills and Walker appear to be engaged in a series of praiseworthy steps to consolidate their establishment in business. In the first place, they are placing local agencies for Autocrat radios throughout New Zealand. Secondly, they have formed themselves into a company under the name of Autocrat Radio Ltd., and finally, arrangements seem to have been successfully concluded for effectively settling the youngest member of this progressive trio, namely Perce Wills. We noted with interest the recent news item in the New Healand "Herald" giving details of his marriage to Miss Nancy Blakey. Congratulations, Perce!

* * *

CLASSIFIED ADVERTISEMENTS

Rates are 3d. a word, with a minimum charge of 2/-. Advertisements must be to hand in this office not later than the fifteenth day of the month in order to be published in the issue appearing about the middle of the following month.

While all care will be taken, no responsibility can be accepted for errors. Advertisements should therefore be submitted either typed or printed in block letters.

Six-volt Radio, A.C./D.C. Canadian R103 MK1. 3-Band. Self-contained Speaker, shock-proof mounting. Suitable launch, caravan. Complete spares. High-efficiency set, beautifully made; new. Best offer around £35. Apply, Tubbs, "Radio and Electronics."

* * *

WANTED TO BUY: Milnes High Tension Units. Please write D. Hughes, 57 Selwyn Crescent, Wanganui.

THE NEW ZEALAND RADIO MANUFACTURERS' ASSOCIATION

Eulogistic reference was made at a recent meeting of the New Zealand Radio Manufacturers' Federation Executive to the services rendered to the radio manufacturing industry by Mr. R. E. (Ron) Dawson, Assistant Federation Secretary, over the past four years, who recently left the Federation staff to take over the secretaryship of the Public Passenger Transport Association. Said Federation President, Mr. W. J. Blackwell: "Mr. Dawson takes with him the warm thanks of all members of the trade and very best wishes for the future."

Mr. D. A. Clarke, of the Federation staff, who takes over Mr. Dawson's duties, was formally introduced to members.

* * *

Deliberations on many matters relating to the local radio manufacturing industry were made at a recent meeting of the Executive of the New Zealand Radio Manufacturers' Federation. In the chair was Mr. Wm. J. Blackwell (President), assisted by the Vice-president, Mr. William L. Shiel, of Dunedin. Auckland manufacturers were represented by Messrs. D. T. Clifton Lewis and E. O. Cox, while Wellington representation was in the hands of Messrs. W. I. Cunninghame, J. M. Gifford, and A. J. Wyness.

Of considerable interest was a decision endorsing the general principle of a national sales publicity campaign along the lines of the American and Canadian "Radio for Every Room" drive. Proposals for the campaign have reached the stage of being considered at meetings of Federation members in each of the main centres with a view to possible early implementation. If the proposals obtain approval, the Federation envisages launching publicity over a period of a month or so per medium of N.B.S., daily newspapers, weekly and other journals. Main theme will probably be: "A Radio for Every Member of the Family—Mum, Dad, Sonny, and Sis." The outcome of these far-sighted proposals will be watched with interest.

Sales tax, too, came in for attention by the national Executive. Arising out of the discussions, a case is to be presented to the Minister of Customs, the Rt. Hon. W. Nash, seeking the remission of sales tax on radio receivers. An interesting point made in the Federation's case is that the radio has become an essential modern amenity in the homes of the people, no less important than normal household furnishings, which are substantially tax-free. Strong representations to the Minister of Customs were also decided upon in connection with such essential raw materials required by the industry as copper winding wire, electrical steel, and panel steel.

In case you haven't a note of it, the Federation's address is **P.O. Box 1605, Wellington, C.1.**

PREDICTIONS FOR THE WORKING OF LONG-RANGE RADIO CIRCUITS ON AMATEUR FREQUENCIES

JULY, 1948

These frequencies are based on world charts of Maximum Usable Frequencies, prepared and issued by the Australian Radio Propagation Committee and supplied to "Radio and Electronics" by courtesy of this body and the New Zealand Department of Scientific and Industrial Research.

Contrary to normal commercial practice in the use of ionospheric predictions, the times given are derived from the Maximum Usable Frequencies, directly, and not from Optimum Working Frequencies, which are 15 per cent. lower.

The circuits are considered workable (a) if the band in question is below the M.U.F. at the time considered, and (b) if the said band is not lower than 65 per cent. of the M.U.F. If (b) is not satisfied, communication is unlikely, not because the frequency is not reflected by the ionosphere, but because the power available to amateurs is too low to overcome absorption in the ionosphere under these conditions.

Where the word "doubtful" appears in the tables, it indicates that between the times so labelled, the band is a little higher than the M.U.F. There is thus a possibility of effective communication on days when the actual M.U.F. is only slightly higher than that predicted.

All circuits have been assumed to start in Wellington. This creates the possibility of some slight error for other starting points, but this is of minor importance only, and does not justify the multiplication of the work involved.

ENGLAND

	N.Z.D.S. Time
Wellington to Liverpool:	
(a) North Route:	
14 mc/sec.	0530 — 0330
30 mc/sec.	Nil
(b) South Route:	
14 mc/sec.	0630 — 1930
30 mc/sec.	Nil

U.S.A.

Wellington to New York:	
14 mc/sec.	0430 — 0330
30 mc/sec.	0700 — 0830 (doubtful)
Wellington to New Orleans:	
14 mc/sec.	0430 — 0330
30 mc/sec.	0600 — 1430
Wellington to Washington:	
14 mc/sec.	0430 — 0330
	0330 — 0430 (doubtful)
30 mc/sec.	0900 — 1500
Wellington to San Diego:	
14 mc/sec.	0430 — 0330
	0330 — 0430 (doubtful)
30 mc/sec.	0630 — 1500

CANAL ZONE AND SOUTH AMERICA

Wellington to Panama:	
14 mc/sec.	0000 — 0230
	0400 — 2030
30 mc/sec.	0600 — 0800
Wellington to Pernambuco:	
14 mc/sec.	0500 — 1900
30 mc/sec.	Nil
Wellington to Buenos Aires:	
14 mc/sec.	0530 — 1030
30 mc/sec.	Nil

AFRICA

Wellington to Dakar:	
(a) South Route:	
14 mc/sec.	0530 — 1900
30 mc/sec.	1030 — 1330
(b) North Route:	
14 mc/sec.	0060 — 0500
30 mc/sec.	Nil
Wellington to Capetown:	
14 mc/sec.	1630 — 1800
30 mc/sec.	Nil
Wellington to Aden:	
14 mc/sec.	0730 — 1700
30 mc/sec.	1330 — 1730

INDIA

Wellington to Karachi:	
14 mc/sec.	0730 — 0630
30 mc/sec.	1330 — 1600
Wellington to Colombo:	
14 mc/sec.	0700 — 0600
30 mc/sec.	1130 — 1730
Wellington to Calcutta:	
14 mc/sec.	0700 — 0600
30 mc/sec.	1130 — 1500
	1700 — 1730

(Concluded on page 48.)

THE EDITOR'S OPINION

TWO NEW EXELRAD OUTPUT TRANSFORMERS

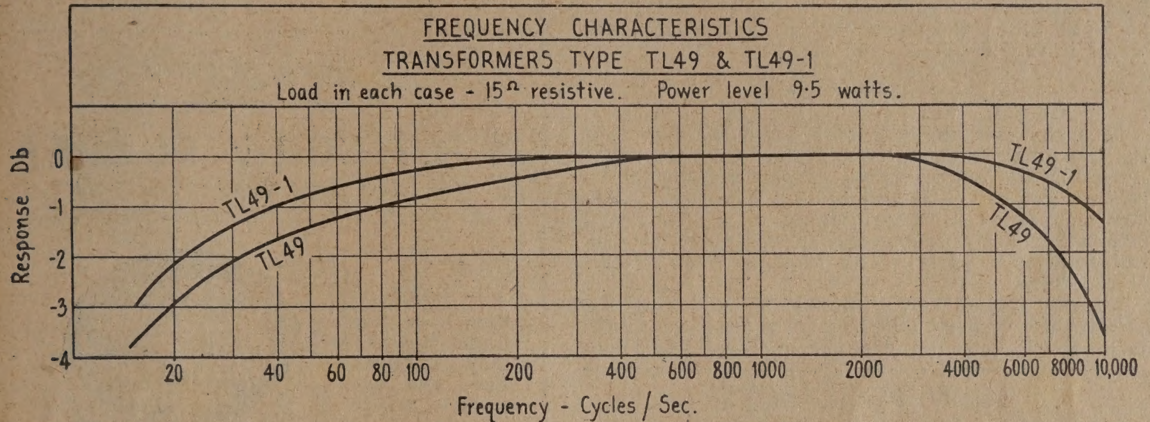
In the range of output transformers that have been available to the public, there has been a notable gap between the cheap, small article, such as those supplied with small loud-speakers, and the transformer with something approaching the best possible performance, and of a price commensurate with its excellence. The latter are not available as multi-match units (for good and sufficient reasons) and in general have to be specially ordered from the few firms who manufacture them.

It is particularly gratifying, therefore, to see that Messrs. Turnbull and Jones Ltd., manufacturers of the well-known Exelrad line of components, have produced two output transformers which will go a long way to bridging the above-mentioned gap. They are designated TL49 and TL49-1 respectively, and although wound on identically sized "Silcore" cores are intended for different applications, and differ consequently in performance and price.

The TL49 is intended for public address and general sound-reproduction work where the desired frequency response is not particularly wide, and in particular, for applications where the wide response typified by the somewhat overworked term "high-fidelity" is neither required nor desirable.

Type TL49-1, however, is intended for applications where a rather wider-than-average frequency response, is needed, but in which the most stringent requirements of the high-fidelity output transformer need not be met.

Both transformers are rated as handling 20 watts of audio power, and are arranged to match push-pull 6L6's (6600 ohms plate-to-plate) to a variety of secondary impedances, ranging from 500 ohms to 2.5 ohms, and embracing the most commonly-found voice-coil impedances.



PERFORMANCE FIGURES

Perhaps the most important single characteristic of an output transformer is its frequency response under loaded conditions. The accompanying curves were obtained by feeding the transformers from an amplifier which is capable of supplying approximately 30 watts at low distortion.

The load impedance consisted of a wire-wound resistor with negligible power-factor at audio frequencies, and capable of dissipating the full output of the transformer without sensible alteration in its value due to heating. While the frequency run was in progress, the wave-form was monitored on a cathode-ray oscilloscope to ensure that no overloading occurred due to any unpredictable cause. It will be noted that in either case the power level at which the frequency run was taken was 9.5 watts. This figure was chosen merely as a matter of convenience, tests indicating that at 20 watts the curves displayed no significant differences.

In addition to measuring the frequency response, an indication of wave-form distortion was sought by using the oscilloscope both with a linear time-base and using a phase-shift picture. The latter is a very sensitive method of indicating the onset of distortion, and consists in placing the input wave on one set of plates and the output wave on the other, without the use of the oscilloscope amplifiers. When no distortion is present, the pattern is either a straight line (when the phase-shift between input and output is either zero or 180°) or an ellipse. Distortion as low as 1% can be observed by this method.

With the TL49, the first noticeable distortion (with the transformer handling 9.5 watts) occurred at 27 c/sec., while the TL49-1 gave a figure of 16 c/sec. under similar conditions.

Power output tests showed that both transformers handled their rated 20 watts without appreciable distortion, except, of course, for the fact that core distortion became noticeable at higher frequencies when the full 20 watts was being handled compared with the figures given for 9½ watts output.

TUBE DATA

(Continued from page 31.)

PRINCIPAL CHARACTERISTICS

Type	V_f	I_f (mA)	V_a	V_{g2}	V_{g1}	I_a (mA)
Mullard DF70	0.625	25	30	30	0	0.375
Mullard DL71	1.25	25	45	45	—1.25	0.6
Mullard DL72	1.25	25	45	45	—4.5	1.25

	I_{g2} (mA)	gm (mA/V)	W	Gain
DF70	0.125	0.175	—	RA = IM Rg = 3M 40
DL71	0.15	0.55	6mW Dt = 10%	—
DL72	0.4	0.5	23mW	—

USE AT OTHER PRIMARY IMPEDANCES

As was stated above, these transformers were designed to operate from a plate-to-plate load of 6600 ohms. This may seem to be unduly restrictive, but there is good reason for so doing, in that had an attempt been made to specify the transformers for other primary impedances, it would not have been possible to keep their excellent performances under all conditions of use. However, with care, there is no reason why they cannot be used to follow push-pull triode, particularly when the valves require a plate-to-plate load impedance smaller than 6600 ohms. Of course, if this is done, the nominal secondary impedances will have to be differently labelled in proportion to the change in plate-to-plate load that has been made. For example, if the plate-to-plate load resistance were changed to 5000 ohms to suit push-pull 2A3's, the secondary tap labelled 15 ohms would in fact match

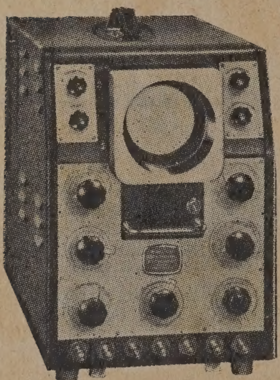
$$\frac{15 \times 5}{6.6} = 11.4 \text{ ohms.}$$

In such cases the low-frequency performance of the transformers would actually be better than that shown in the above curves. However, care should be exercised if it is desired to alter the plate-to-plate load impedance to values higher than 6600 ohms, although entirely satisfactory performance can be had from type TL49-1 with loads as high as 9000 ohms.

To sum up, it can truthfully be said that the performance of these transformers is excellent within their intended spheres of application, and that many uses will be found for them in cases where their very reasonable price, in conjunction with their known characteristics, makes them the most economic proposition, as distinct from either much more expensive or from cheaper output transformers.

NEW PRODUCTS

Cossor Model 1035 Double Beam Oscillograph Using a Flat Screen Tube



We wish to advise readers that through a regrettable oversight, the article in last month's "New Products" section, describing the new Cossor Model 1035 oscilloscope, contained no reference to the fact that the agents for this equipment are Messrs. Swan Electric Co., Ltd. We make haste to rectify that omission, and to point out to interested readers that prices and further information may be obtained from the above-mentioned firm.

AMATEUR FREQUENCY PREDICTIONS

(Continued from page 46.)

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Wellington to Hong Kong:

14 mc/sec.	0630 — 0530
30 mc/sec.	0830 — 1430

Wellington to Singapore:

14 mc/sec.	0900 — 0600
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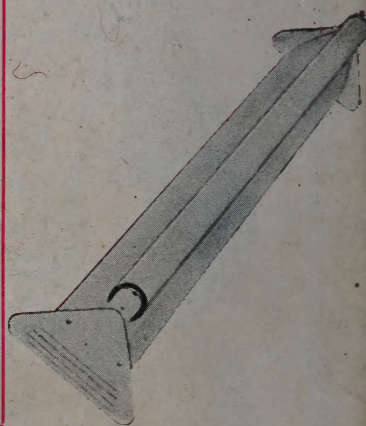

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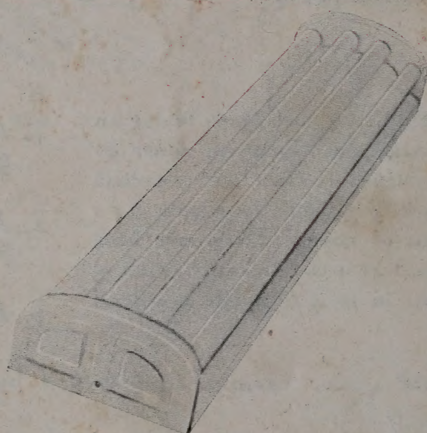

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